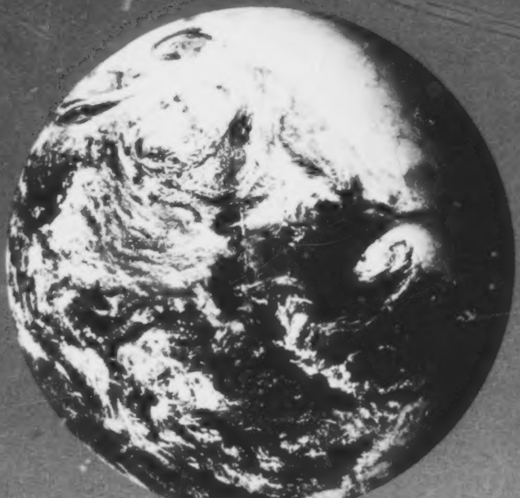
Environmental Quality

21st Annual Report

The Council on Environmental Quality

Executive Office of the President of the United States



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ENVIRONMENTAL QUALITY

The Twenty-First Annual Report of the
Council on Environmental Quality together with
The President's Message to Congress

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THE PRESIDENT'S MESSAGE ON ENVIRONMENTAL QUALITY

To the Congress of the United States:

Of all the great social and technological changes of the 20th century, none may be more crucial to our wellbeing and that of future generations than the change that has occurred in the way we view our environment. Ours was the first generation to see the many colors of Earth from the vastness of space, and to recognize that our decisions will determine whether the next generation lives in a polluted world of lowered expectations or in a world that sustains humanity and a wondrous diversity of life.

Given these high stakes, I am pleased to report that 1990 was a landmark year in the nation's efforts to enhance environmental quality.

- We enacted the Clean Air Act Amendments of 1990, providing the United States with the world's most advanced, comprehensive, and market-oriented laws to address air pollution, including acid precipitation, urban air quality, toxic air pollutants, and global ozone layer depletion.
- We adopted an international agreement and enacted laws to phase out chlorofluorocarbons (CFCs) and other substances that deplete the Earth's ozone layer, which protects us from the harmful effects of solar radiation.
- We enacted the Oil Pollution Act of 1990 and adopted a major international agreement to strengthen laws related to oil pollution prevention, liability, and response.
- We enacted the most environmentally progressive farm bill ever. It will help farmers protect water quality and wildlife habitat, and it launches a part of our America the Beautiful initiative to begin a long-term national tree planting and improvement campaign aimed at both rural and urban areas.

- In partnership with the nation's governors, we developed ambitious national educational goals, while Congress and the Executive Branch strengthened environmental education programs. These actions are an essential part of our efforts to revitalize American education and improve the environment.

- We made many other commitments to environmental stewardship, including the expansion of national parks, wildlife refuges, marine sanctuaries, and recreation areas; accelerated cleanup of federal facilities; enhanced protection of marine mammals, the African elephant, the Florida panther, and other threatened species; and the suspension for up to ten years of oil and gas leasing in many areas off our coastlines pending further environmental and resource analysis.

The complete record is told in this report. I am proud that our Administration played a catalytic and constructive role in securing these achievements. Progress has come from working cooperatively with the Congress, state and local governments, environmental and conservation groups, corporations, educators, and scores of individuals, as well as other nations and international institutions.

Our achievements in 1990 add to a growing national record of environmental action that has improved the quality of American life. Compared to the conditions facing Americans earlier in my lifetime, our skies are clearer, our lakes and streams are cleaner, and our major technologies are less wasteful.

Our work, however, is incomplete. Americans are sobered by the scope of the stewardship challenge and recognize that it requires ongoing vigilance and action. We know, for example, that increased trade and economic development are needed to reduce poverty and improve the quality of life for all of the world's people. However, if we fail to make wise economic and environmental choices, those needed increases in economic activity are likely to result in new burdens on the Earth's ability to sustain life. Our challenge is both to provide greater opportunities for an expanding population and to protect the environment upon which we depend.

Several forces work in our favor. Our economy is fundamentally sound, which allows us to make environmental investments and serve as a model for others. Our technology is first-rate, as is our research establishment. Our citizens are eager to make a personal contribution.

In the days ahead, therefore, we must summon the full measure of our powers to achieve environmental results. In that effort, we should be guided by what science tells us about the most serious threats to our health and environment and also by our knowledge of what works and what does not.

In particular, we must learn to harness wherever possible the power of the marketplace in service to the environment. The goal of a healthy environment may not be provided by markets acting alone. However, government regulations are blunt tools that impose unforeseen human costs. Therefore, we need to consider all costs and benefits of government programs as they are developed and expand the use of market incentives that deliver results at the lowest possible cost to society. As a corollary, we need to strengthen the base of scientific and economic understanding that supports such decisions.

Our environmental efforts should also be guided by a holistic view. The environment is composed of a seamless web of relationships between living organisms and the air, water, and land that surrounds them. Accordingly, rather than continue to address environmental issues in isolation from each other or from other social goals, we must expand our efforts to understand and protect the functional integrity of the environment—and our place in it.

We can also apply American ingenuity to the challenge of preventing pollution. There is no reason to think of pollution as an inevitable problem that occurs at the end of a pipe. Quite the contrary: as pollution becomes more costly, and because we recognize the environment is an enclosed sphere, we are finding that pollution prevention can be less costly *and* better for the environment.

Our efforts to enhance the quality of the domestic environment must be accompanied by comparable efforts toward global environmental quality. In these times, Americans are aware that our political and economic security are affected by actions occurring abroad. Likewise, we know that environmental threats do not stop at a line on a map. In the months and years ahead, we need to broaden our dialogue with other nations and international institutions and together address environmental issues that know no boundaries.

At home, two further principles will guide our environmental policies. First, we will continue to harness the enthusiasm and expertise of citizen volunteers. Partnerships between the public and private sectors have always been a key to our success, and their value in environmental affairs is growing. Second, we will continue to enforce environmental laws firmly and fairly. Our record and our message in this regard is absolutely clear: polluters must pay.

Taken together, these principles—and the new programs and initiatives that are putting them into action—represent a turning point in American environmental affairs. No longer should we as a nation focus on isolated fragments of what is in fact a complex, interconnected set of problems. Nor should we accept rigid, short-sighted measures that stymie innovation, shift pollution from one location to another, or impose unnecessary costs. In the future, our national environmental strategy must be comprehensive, long-range, efficient, and adaptable to changing information about risks and benefits.

In the coming months, our Administration will pursue a number of new initiatives to advance these principles. For example, in December 1990 I established by Executive Order the President's Commission on Environmental Quality. This Commission will soon be at work building public-private partnerships to help achieve concrete results in the areas of pollution prevention, conservation, education, and international cooperation. A program of Presidential awards for achievement in conservation and environmental affairs will stimulate voluntary activity and recognize the outstanding efforts of individuals and organizations. Each of these projects is intended to underscore my belief that environmental stewardship must flow from action by all Americans, not just from government action.

In the legislative arena, our Administration will work with the 102nd Congress toward enactment of amendments to the Clean Water Act and other environmental laws, seeking opportunities to incorporate innovative, market-oriented provisions. We will also seek to make progress toward the goal of no-net-loss of wetlands, and to strengthen programs to revitalize the Great Lakes, the Chesapeake Bay, and other productive ecosystems. And we will work for a National Energy Strategy that provides a balance among the goals of increased energy efficiency, increased use of alternative fuels, and environmentally responsible development of all U.S. energy resources.

I have proposed that the Congress give the environment a permanent place at the Cabinet table by creating a U.S. Department of the Environment. Given the importance of environmental matters, both domestically and internationally, the Environmental Protection Agency is already accorded equal status with other major federal departments in my Administration. However, I feel this policy should be established in law for the future. The Congress should reject extraneous provisions that would delay consideration of this proposal.

Looking abroad, the United States will continue to seek to conclude an international convention on global climate change in time for its signing at the 1992 United Nations Conference on Environment and Development in Brazil. In our view, such a convention must be comprehensive in scope, addressing all sources and sinks of greenhouse gases, adaptation as well as mitigation measures, and continued scientific and economic research and policy responses. The United States is committed to a series of domestic actions that have many benefits such as curbing air pollution, conserving energy, and restoring forest lands and that also help to curb greenhouse gas levels. These actions—recently established in law or proposed by my Administration—will hold U.S. net emissions of greenhouse gases at or below the 1987 level through the foreseeable future. An effective response to potential climate change also requires that all nations participate and meet obligations that are appropriate to their circumstances.

I have also proposed that a worldwide convention on forests be developed and ready for signing by world leaders at the U.N. conference in 1992. Forests provide diverse benefits, helping to clean our air and water, foster biological diversity, and sequester greenhouse gases. We should take steps now to protect and enhance them. In the coming year, I also hope we can move forward on U.S. proposals for integrated economic and environmental assistance in such regions as Latin America and the Caribbean, Eastern and Central Europe, and the Middle East.

Also, the worldwide market potentially available for U.S. exports of environmental goods and services approaches $60 billion annually, and it is growing. I have directed the Department of Commerce to assess that market, and I look forward to the creation of a partnership between business and government to develop the opportunities for environmental technology exports. This effort will help to create new jobs while enhancing the quality of life here at home and around the globe.

The causes and effects of environmental problems are diverse and complex. We should be humbled by the fact that the more we learn, the more questions arise. But unlike the situation a generation ago, we know today that ecological degradation can be halted and, indeed, reversed through rigorous analysis, constructive dialogue, and hard work. Let us work together in this generation to achieve a more productive harmony between humanity and the environment.

Bush

GEORGE BUSH
The White House
April 1991

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL ON ENVIRONMENTAL QUALITY
WASHINGTON, DC 20500

LETTER OF TRANSMITTAL

The President:

Sir: The Council on Environmental Quality herewith submits its Environmental Quality Report for the year 1990 in accordance with section 201 of the National Environmental Policy Act of 1969 (42 U.S.C. 4341).

Respectfully,

Michael R. Deland

Michael R. Deland
Chairman

D. Valdez, The White House

The President confers with the Chairman of the Council on Environmental Quality in accord with the National Environmental Policy Act of 1969, which states:

> ***It shall be the duty and function of the Council . . . to develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the Nation . . .***

FROM THE CHAIRMAN

Behind all the studies, the figures, and the debates, the environment is a moral issue. We can and should be nature's advocate.

—President George Bush
June 8, 1989

The charge from President Bush is clear. With this, the second *Environmental Quality* report of the Bush Administration and the twenty-first for CEQ, we hope to record and further encourage the nation's environmental vigor. This year's report outlines a national environmental strategy for the 1990s, discusses trends in environmental quality and policy, reviews selected federal programs, and recommends future policy directions. Each chapter addresses promising new approaches to environmental quality. The issues and ideas discussed in these chapters range across many government agencies and many sectors of society.

- **"Where We Stand" (Chapter 1)** sets out a comprehensive six-point national strategy for environmental quality in the 1990s, at home and abroad. The strategy's fundamental principles already are embodied in a number of Administration programs and initiatives. The chapter also reviews the environmental efforts since 1989 of the Bush Administration and the 101st Congress.

- **"Making the Environment Count" (Chapter 2)** describes many ways the environment counts today--and should count in the future—in economic and political decisions. Harnessing the power of the marketplace to serve environmental interests is a key component of the Administration's environmental strategy.

- **"Technology for Pollution Prevention" (Chapter 3)** picks up the theme of convergence of economic and environmental decisionmaking and explores the technical and managerial aspects of a promising trend in environmental policy—pollution prevention. Increasingly, it pays to prevent pollution in the first place rather than spend billions of dollars to clean it up at the end of a pipe.

- **"Linking Ecosystems and Biodiversity" (Chapter 4)** addresses a subject that cuts across many fields of inquiry and many government programs. This year's report focuses on the conservation of domestic biological diversity and its connection with a trend that is promising in its own right—ecosystem management.

- **"The National Environmental Policy Act" (Chapter 5)** explores the federal policy established by that visionary statute: ". . . to create and maintain conditions under which man and nature can exist in productive harmony." Because government mandates may at times conflict with one another, Chapter 5 outlines how the NEPA process can integrate efficiently the requirements of environmental and other laws. This chapter also presents abstracts on selected NEPA court cases in 1990, along with the latest data on NEPA trends.

- **"Environmental Data and Trends" (Part II)**, a regular feature of the *Environmental Quality* report, contains updated data describing the status and trends in American natural resources and the environment. This section draws on information supplied by numerous government and nongovernment sources. The data is augmented with text and graphics to make the tables more meaningful for specialists and nonspecialists alike.

Given that pollution does not respect international boundaries, we address global environmental issues in Chapter 1. This year, CEQ also is overseeing the preparation of the U.S. National Report to the United Nations Conference on Environment and Development (UNCED) to be held in 1992. Under guidelines adopted by the United Nations, many countries will bring such reports to the conference, collectively forming a database on international environmental conditions and policies. These reports will therefore serve as a backdrop to ongoing deliberations on global, environmentally sustainable development.

Activities of the Council on Environmental Quality

The National Environmental Policy Act sets out three critical missions for the Council on Environmental Quality:

- advising the President, his Cabinet, and the White House staff on environment-related issues;
- overseeing federal agency implementation of NEPA itself; and
- collecting, analyzing, and reporting data on conditions and trends in the environment.

In fiscal 1990 at the President's initiative, CEQ was transformed from a small staff of less than 10 to an interdisciplinary team of 28, enabling the Council once again to meet its NEPA mandates and assist with all Presidential actions related to the environment. Some representative examples of CEQ initiatives in 1990 follow:

- **Climate Change.** The CEQ chairman served as Vice Chair of the Domestic Policy Council's Working Group on Climate Change, and Co-Chair of the White House Conference on Global Change. CEQ also was involved in global negotiations on climate change.

- **Education.** CEQ prepared a comprehensive assessment of existing federal environmental education programs and worked with Congress on a proposal, ultimately enacted into law, authorizing presidential awards to teachers for excellence in environmental education.

- **Energy.** CEQ consulted with the President, his Cabinet, and White House staff regarding fuel supply and energy efficiency issues in the immediate wake of the Iraqi invasion of Kuwait. CEQ also worked with federal colleagues in the area of energy efficiency and advised President Bush and Cabinet secretaries on the decision to suspend oil and gas leasing in large areas of the outer continental shelf, pending further environmental and resource analysis.

- **NEPA Environmental Reviews.** CEQ worked with the Department of Defense on emergency arrangements under NEPA for certain activities related to Operation Desert Shield and Desert Storm, with the Resolution Trust Corporation (RTC) regarding the application of NEPA to the disposal of real property assets, and with 18 agencies seeking guidance on compliance with environmental review procedures for federal activities abroad. CEQ also is developing a generic, long-range NEPA compliance initiative for all agencies.

- **Pollution Prevention.** CEQ developed outreach efforts to corporations, associations, and the media on the challenge of pollution prevention. The Council also helped develop the Administration's national pollution prevention strategy and encouraged other federal entities to adopt pollution prevention strategies, including energy efficiency, in their ongoing programs.

- **Recycling.** CEQ helped to initiate recycling in the Executive Office of the President and encouraged recycling in other Executive Branch agencies.

- **U.S.-Soviet affairs.** CEQ convened a conference in Alaska to promote the establishment of a joint U.S.-Soviet park in the Bering Sea region. CEQ also provided information and advice on environmental law to Soviet officials and nongovernment groups.

- **Wetlands.** CEQ continued its work as a member of the Domestic Policy Council's Task Force on Wetlands to make progress toward President Bush's "no-net-loss" goal.

The duties of the Council involve top-down communication and coordination of the President's environmental objectives as well as promotion of concepts and programs from the grass roots that complement the President's agenda. For example, in 1990 CEQ solicited quarterly information from the various Executive departments and agencies on their environmental initiatives and accomplishments. CEQ compiles this information for the President and disseminates it to senior Administration officials as an aid to policy planning, evaluation, and communication.

The Council also works with nongovernmental leaders in stewardship of the environment. For example, beyond the interaction required by our daily business, President Bush recently established by Executive Order the President's Commission on Environmental Quality (PCEQ), to be chaired by CEQ. The Commission will be comprised of business, environmental, and academic leaders. While the PCEQ is empowered to advise the President on the full range of environmental matters, it will focus on creating results-oriented partnerships in the areas of pollution prevention, conservation, education, and international cooperation.

A key purpose of NEPA was to create an institution that would "develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the Nation." To meet that challenge, we at CEQ must coordinate and conciliate across the entire breadth of the government and society. We try to look beyond the next law and regulation, cognizant of our responsibility under NEPA to serve as trustee of the environment for succeeding generations. That is a high calling, one to which we at the Council—on behalf of the President—are dedicated wholeheartedly.

Acknowledgments

The CEQ staff who prepared this report have earned our gratitude and praise for their substantial, conscientious efforts. Particular credit is due Dale Curtis, my Special Assistant, who served as Editor-in-Chief, and Barry Walden Walsh, the Managing Editor. The following CEQ staff took the lead for research and writing:

- **Chapter 1, "Where We Stand":** Dale Curtis, who gratefully acknowledges the assistance of colleagues across the Executive Branch.
- **Chapter 2, "Making the Environment Count":** Scott Farrow, CEQ Associate Director for Pollution Prevention and Control, with research assistance from David Wigder.
- **Chapter 3, "Technology for Pollution Prevention":** Colonel Frank Skidmore (U.S. Army Corps of Engineers), CEQ Technology & Engineering Advisor, and Mary Holland, CEQ Senior Policy Analyst, with helpful contributions by Christine Bogdanovich, intern.
- **Chapter 4, "Linking Ecosystems and Biodiversity":** Robin O'Malley, CEQ Associate Director for Natural Resources, and Barry Walden Walsh.
- **Chapter 5, "The National Environmental Policy Act":** Carl Bausch, Lucinda Low Swartz, Michelle Wiseman (Fellow, Department of Commerce), and Sara Nero, all of the CEQ General Counsel's Office, under the direction of Dinah Bear, CEQ General Counsel.
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Finally, we are indebted to numerous Executive Branch colleagues who contributed their expertise, read the manuscript, offered constructive advice, and checked our facts. The contents of the report remain the sole responsibility of the Council on Environmental Quality.

Michael R. Deland
The White House
April 1991

PART I

SPECIAL REPORTS

EXECUTIVE OFFICE OF THE PRESIDENT OF THE UNITED STATES

COUNCIL ON ENVIRONMENTAL QUALITY

C. Powers, The White House

At the signing of the Clean Air Act Amendments of 1990, the President spoke for both his Administration and the Members of Congress when he stated:

> ***Now we know: we can establish a new kind of environmentalism, one in which a sound ecology and a strong economy go hand-in-hand.***

CHAPTER 1

WHERE WE STAND

Last year the annual report of the President's Council on Environmental Quality[1] marked the Council's twentieth anniversary with a retrospective on U.S. environmental policy over the period 1970-1990. That era opened with the signing of the National Environmental Policy Act (NEPA), the "Magna Carta" of U.S. environmental policy, on New Year's Day 1970. NEPA was significant not only because it created the Council on Environmental Quality, but also because it embodied the concept that the nation needs to consider all effects on the environment—direct, indirect, immediate, and cumulative—in the decision-making process for all policies and programs. By the close of 1970, the nation's ingrained love of its natural heritage had blossomed with the first Earth Day celebration, enactment of landmark clean air and other environmental legislation, and creation of new federal agencies to promote environmental quality—the Council on Environmental Quality (CEQ), the Environmental Protection Agency (EPA), and the National Oceanic and Atmospheric Administration (NOAA).

Last year's CEQ report concluded that over the past two decades the nation's environmental policies improved steadily and, from a cumulative point of view, substantially. Progress tended to be uneven, however, as the nation addressed environmental, energy, and economic problems in sequential bursts of activity. As the twentieth anniversary of Earth Day approached in 1990, most Americans were demanding a new, more coherent strategy for environmental quality.

Recognizing the need for environmental protection, expanding supplies of energy, global economic development, and competitiveness, the nation began to identify and implement policies to integrate economics, energy, and the environment. Such priorities need not be at odds—indeed, they are inextricably linked to one another. The term "sustainable development," adopted as a goal by the World Commission on Environment and Development,[2] captured the moral and practical imperative that today's economic development must not endanger the wellbeing of future generations. The same thought was expressed over a century ago in timeless language by the Native American Chief Seattle, who said, "We do not inherit the Earth from our ancestors—we borrow it from our children."

A National Strategy for Environmental Quality

As the nation and the world embraced the goal of sustainable development in 1990, the Bush Administration developed a National Strategy for Environmental Quality. Published here for the first time, the strategy incorporates domestic and international elements, acknowledges public and private sector roles, and applies to immediate- and long-term actions. The strategy is based on several principles already embodied in a number of programs and initiatives:

- Harnessing the Power of the Marketplace;
- Stewardship;
- Creative Partnerships;
- Cooperative International Solutions;
- Preventing Pollution; and
- Vigorous Law Enforcement.

Harnessing the Power of the Marketplace

Conventional wisdom once held that market-oriented economic growth and effective environmental protection were at odds. However, economic scholars have recognized for years that the two are in many respects complementary. For example, economic growth under competition stimulates firms to invest in new facilities that are more resource- and energy-efficient than their predecessors. Likewise, the long-term growth of nations depends on the wise use of such natural resources as topsoil, water, forests, and minerals. By contrast, the sad conditions in many nations demonstrate how highly centralized economic planning harms both economic growth and the environment.

Compatibility between economic growth and the environment is not automatic; it depends on the selection of goals and the design of management and regulatory programs. Thus, an essential element of any successful environmental strategy must be the design of policies to mesh well with economic and other national goals. Experience shows that the environment is best served when government examines existing and potential environmental problems, sets priorities according to the relative risks of those problems, and creates incentives for the private sector to work out the most cost-effective responses to national environmental goals. In other words, governments should seek to harness the power of free enterprise in ways that serve the interests of the environment.

Chapter 2, "Making the Environment Count," explores issues relating to economics and the environment, but two examples follow here.

Marketable Allowances for Air Pollutants

In many respects, the Clean Air Act Amendments of 1990[3] are a product of the economic-environmental convergence. The amendments authorize the distribution of "allowances" to coal-burning electric utilities whose facilities emit sulfur dioxide, a precursor of acid precipitation. The federal government will issue these allowances to utilities, which can then buy and sell them in the open market. The quantity of allowances will be large enough to create an active market yet limited enough to force continuing emission reductions since emissions in excess of allowances are prohibited. Overall, the program will reduce national utility sulfur dioxide emissions by roughly 50 percent below 1980 levels, with reductions concentrated in regions where coal-related emissions are the largest.

The marketable allowance system creates incentives to achieve the desired level of emission reductions at least cost. Electric utilities that make larger-than-required emission cuts can save excess emission allowances for future use, or they can sell them to others. Since utilities are free to choose compliance strategies, they can be expected to hold down the costs of emission reductions, to the benefit of electric ratepayers and utility stockholders. In many cases, a cost-effective emission reduction strategy will mean investments in more efficient technology and conservation, restraining utility emissions.

In a similar fashion, the federal government is using taxes and marketable permits that create economic incentives to phase out ozone-depleting substances in a relatively rapid, cost-effective manner.

Contrast these market-oriented approaches with the 1977 Clean Air Act Amendments that regulated sulfur dioxide by requiring every new and significantly modified coal-burning powerplant to install the best available control technology. While this approach restrained sulfur emissions below what they otherwise would have been in areas where new plants were being constructed, it failed to recognize regional variations in levels of existing pollution. Further, it created an incentive for firms to extend the life of older, dirtier plants without upgrading their controls, rather than build the more costly but cleaner and more energy-efficient new plants.

Environmental Investments Abroad

Another way to harness the power of the marketplace in service to the environment is to promote environmentally sensitive investment in developing countries. The worldwide market potentially available for U.S. exports of environmental goods and services approaches $60 billion annually. Also, many developing countries, especially those carrying heavy debt burdens, are rapidly depleting their stock of natural resources, such as timber, to reduce an unfavorable balance of trade. American companies and government bodies have a great deal to offer in response to these issues.

For example, in October 1990 the Overseas Private Investment Corporation (OPIC), a self-sustaining U.S. government agency, helped to create a $100-million investment fund for new or expanding enterprises in developing countries that practice sound environmental management. Under this initiative, OPIC will contribute up to $40 million; the remaining $60 million is being raised through the sale of limited partnership interests to U.S. firms and institutional investors. The fund, which will be privately owned and managed, seeks investments in the following fields:

- Sustainable agriculture and forest management,
- Ecologically oriented tourism,
- Renewable and alternative energy technologies, and
- Pollution prevention technologies (see Chapter 3, "Technology for Pollution Prevention," for a discussion on ways to reduce pollution by eliminating it at the source).

Stewardship

The world's abundant natural resources must be managed wisely if their availability for future generations is to be assured. Several terms are in use for this guiding principle: conservation, sustainable development, or stewardship. Since the early years of this century, stewardship of natural resources has been a fundamental value of the American people.

Human activities must proceed, yet the functional integrity of natural systems is essential, for it is these systems that support and renew life on Earth. Achieving the goal of the National Environmental Policy Act—to create a "productive harmony" between humans and nature—requires consideration of ecosystems as functional units. Chapter 4, "Linking Ecosystems and Biodiversity," considers the implications of this subject.

Over the years, support for conservation programs has varied, but 1989-1990 saw the momentum of American conservation regained. A profile of major initiatives follows.

America the Beautiful

The America the Beautiful initiative aims to protect, preserve, and expand America's national treasury of parks, forests, wildlife refuges, and other public lands. As one facet of the initiative, the Department of the Interior (DOI) and the Department of Agriculture (USDA) are acquiring new federal lands with significant environmental or recreation value. Funding under the Land and Water Conservation Fund went up from $171 million in fiscal 1988 to $342 million by fiscal 1991. Another component of the initiative will increase the number of boat ramps, campsites, trails, and interpretive centers for America's growing population of outdoor enthusiasts; and improve access for disabled Americans. Legacy '99 is a complementary DOI program to upgrade conditions at national parks, wildlife refuges, and other public lands by the end of the decade.

In yet another facet of America the Beautiful, the President's Tree Planting Initiative is establishing a long-term reforestation program to plant and maintain one billion new trees annually for at least ten years. In the first-ever forestry title to omnibus farm legislation, Congress authorized a one-time grant to the private, nonprofit National Tree Trust Foundation, to leverage nonfederal funds and activities for the tree planting program. The foundation will help support the efforts of community tree planting groups and encourage Americans to participate directly in tree planting activities. The legislation also authorizes the USDA Forest Service to work with state and local governments, land grant universities, and the private sector to improve the management of private forests and those in urban areas.

Wetlands

To address the need to reduce wetland losses and also register wetland gains, the Administration and Congress have devoted considerable budget resources to wetland programs. The fiscal 1991 appropriations for existing wetlands programs, including the national wetlands inventory and the bay/estuary program, included a 17-percent boost over fiscal 1990, following a 38-percent increase in 1990 over 1989 levels. The

Administration's fiscal 1992 budget request for all wetland activities totals $709 million, a 48-percent increase over the enacted 1991 level.

In 1990 Congress passed legislation[4] authorizing the federal government to spend up to $26 million a year to purchase wetlands to implement a 1986 U.S.-Canadian agreement, the North American Waterfowl Management Plan. Among various wetlands acquisitions, projects, and legislation over the past two years, the Department of the Interior added 106,000 acres to the Everglades National Park in Florida and tripled wetlands acreage in the area of Kesterson Reservoir in California.

During the summer of 1990 the President's Domestic Policy Council Task Force on Wetlands held public meetings in six regions of the country to obtain public comment on appropriate strategies for working toward the President's goal of "no-net-loss of wetlands."

Enhanced criminal enforcement and tough, highly publicized sentences for those who filled wetlands illegally are proving to be an effective deterrent to wetlands loss.

Offshore Development Moratorium

In a package of decisions recognizing the importance of both environmental concerns and domestic oil and gas supplies, the President postponed for at least ten years offshore oil and gas lease sales in selected areas, pending further studies concerning the environmental and resource characteristics of the areas. The tracts affected comprise 99 percent of the California coast, the entire coasts of Oregon and Washington state, the southwest coast of Florida, and the Georges Bank area off New England.

Creative Partnerships

The majority of U.S. lands are in private hands, with a large proportion of private lands owned by corporations. Therefore, as a nation, we must promote partnerships between the public and private sectors to maintain a sound environment and economy. Local residents are among the most knowledgeable advocates of protecting local natural resources, and partnerships that harness their expertise are crucial, especially on such projects as conserving wildlife habitats. In response to the initiative of private groups such as Trout Unlimited, B.A.S.S., Defenders of Wildlife, and The Nature Conservancy, the federal government is conducting cooperative management and research projects involving citizen volunteers and personnel from the USDA Forest Service, the Department of Defense, and the Department of the Interior's Bureau of Land Management and Bureau of Reclamation.

Partnerships are equally applicable in the areas of energy and manufacturing where, for example, environmental groups, states, and electric utilities are teaming up to design energy efficiency programs to reduce future electricity requirements.

Cooperative programs are a priority of the President's Commission on Environmental Quality (PCEQ), which was established by Executive Order #12737 in December 1990 and will be comprised of leaders from business, academia, and the environmental community. The commission will take a results-oriented, cooperative approach in the areas of industrial pollution prevention, conservation, and education, both at home and abroad.

As evidence of the environment-economics convergence, the nation is witnessing alliances that would have seemed impossible a few years ago. Not just a passing fad, cooperative partnerships have become an integral element of U.S. environmental policy.

Cooperative International Solutions

A new strategy for environmental quality requires not only that the United States merge the pursuit of environmental and economic goals at home but also that the nation recognize the global, transboundary dimensions of the challenge. Massive flows of goods, services, and capital cross international borders each day. At the same time, some human activities are eroding the natural regenerative ability of the Earth's atmosphere, oceans, soils, and biological diversity. In an age of emerging technologies and ever greater aspirations for development, the demand for clean economic growth is increasing not only in industrialized countries but also in the developing nations.

International efforts for sustainable development intensified in the last two years. Such efforts are likely to become more prominent in the years ahead as research produces information and new understanding and as environmental diplomacy gains momentum.

Ozone Layer Depletion

Among the most significant events of the past two years was the adoption in 1990 of the London Amendments to the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer.[5] This landmark agreement joined dozens of nations in a combined effort to address an emerging environmental problem: deterioration of the Earth's stratospheric ozone layer that shields the planet's surface from harmful solar radiation. The pact requires the phaseout of most uses of ozone-depleting substances such as chlorofluorocarbons (CFCs) by the year 2000 and includes provisions to assist developing countries with the transition to safer substitutes. Because CFCs and related chemicals are also potent greenhouse gases, their rapid phaseout and replacement by safe alternatives will help to avert potential changes in global climate patterns.

CASE STUDY

The Tennessee Valley Authority: Environmental Principles in Action

The Tennessee Valley Authority, a government-owned corporation, conducts a resource development program to advance economic growth in the Tennessee Valley region. TVA's vision for the 1990s emphasizes a convergence of economic and environmental interests. As part of its commitment to become a leader in solving environmental problems of national concern, TVA adopted new operating principles in 1990:

- Comply with the spirit and the letter of environmental law and, in some cases, adopt more stringent standards.
- Apply best-management practices on TVA lands and lakes, recognizing that land-use practices can have a profound effect on water quality.
- Reduce waste generation from TVA facilities, redesign industrial processes as necessary, and cooperate with the region's industries and communities to develop markets for products developed from waste materials.
- Insist on public scrutiny and consultation to ensure that proposals are in the best interest of the people.
- Help solve environmental problems that present obstacles to development.
- Train TVA employees to understand environmental responsibilities and contribute to environmental education around the nation and the world.
- Create a TVA laboratory to address regional and national environmental issues, including technology transfer.
- Consider demand-side management options for power generation along with environmentally responsible powerplant designs.

Action plans will focus initially on waste management, river and watershed management, and air quality. Projects in these areas include the following:

- **Refuse-Derived Fuels.** TVA and local communities are working to develop environmentally sound solid waste management. Proposals include a plant to produce electric energy from municipal solid wastes and technology to convert up to three-quarters per ton of municipal solid wastes into useful products.

- **Constructed Wetlands.** Working with local, state, and federal partners, TVA is demonstrating how constructed wetlands can treat runoff and wastewater from many sources.

- **Animal Wastes.** Livestock and poultry account for half the income from farm products in the region, but the volume of livestock wastes equals the untreated sewage of 47 million people—nearly seven times the region's population. TVA, USDA, land grant universities, and farmers are setting up demonstration farms to convert livestock wastes into products.

- **Hardwood Chip Mills.** Paper companies plan to build 11 hardwood chip mills along the Tennessee River—mills that would create jobs and a market for low-grade hardwood timber but also would impact land and water quality. TVA is measuring these impacts and preparing guidelines to help avoid or mitigate them.

- **Environmental Leadership Center.** Land Between the Lakes, a TVA research and training center, is slated to become an International Biosphere Reserve in 1991. Plans include a new training program for local leaders and international visitors.

- **Integrated Gasification Combined Cycle and Fertilizer Co-Production Process.** TVA and the Electric Power Research Institute are developing an innovative coal-fired plant to produce both electricity and fertilizer. The co-production process (IGCC/F) reduces sulfur dioxide and nitrogen oxide emissions; produces a nonleaching, marketable, glasslike slag; and converts part of the carbon dioxide emissions into urea that can be sold as a fertilizer or burned in boilers to further remove nitrogen oxides from exhaust gases.

- **ADVACATE Scrubber Technology.** TVA and EPA are testing a dry scrubber technology for removing sulfur dioxide emissions from coal-fired plants. ADVACATE technology may be as effective as wet scrubbers in meeting acid rain requirements yet cost half as much to build. Unlike wet-scrubber wastes, ADVACATE wastes are dry and easy to handle and may have economic potential as filler for cement and other uses.

- **Toxic Air Pollutants.** An air-monitoring station on Fort Loudoun Lake has found levels of PCBs, dioxin, and furans in the air and rain comparable to levels in the Great Lakes area, where toxic air pollutants contribute to lake contamination. TVA, EPA, and state and local regulatory agencies are monitoring and studying such air pollutants in anticipation of mitigation programs.

Global Climate Change

The United States is active in international efforts to research and respond to the prospect of climate change. During 1989-1990 the federal government developed and implemented the U.S. Climate Change Strategy, which will result in U.S. greenhouse gas emissions in the year 2000 being equal to or below the 1987 level. Congress appropriated $952 million for climate change research in fiscal 1991, and the Administration requested almost $1.2 billion for fiscal 1992—far more than any other nation is spending. In 1990 the United States hosted a multinational symposium on science and economics research related to global change and prepared to host the opening session of international talks toward a multilateral framework treaty on climate change.

The U.S. climate change policy is consistent with the findings of the U.N.-sponsored Intergovernmental Panel on Climate Change (IPCC). Assessments by IPCC, the leading global forum for climate change science and policy analysis, are the product of work by hundreds of experts worldwide. The IPCC First Assessment Report[6] concluded that emissions resulting from human activities are substantially increasing the atmospheric concentrations of gases that trap heat in the atmosphere and that these increases will enhance the atmosphere's natural greenhouse effect, resulting on average in additional warming of the Earth's surface. Based on current computer models and a business-as-usual scenario (that is, if current policies and trends continue), IPCC predicted that the global mean temperature on Earth's surface could increase about 0.3 degrees Centigrade per decade during the next century. IPCC noted large uncertainties with regard to the timing, magnitude, and regional patterns of climate change—including the effects of climate change on society and the environment—and recommended that national policies have the following characteristics:

- Beneficial and justifiable now in their own right;
- Economically efficient and cost-effective; and
- Flexible and phased so that they can be modified in response to evolving scientific and economic knowledge.

The report emphasized the need for a comprehensive approach to climate change—one that addresses all sources and sinks of greenhouse gases as well as adaptations to change. Such an approach will require commitment from both industrialized and developing countries.

The IPCC criteria are similar to those proposed by the United States in January 1989 and advanced by U.S. policy during the past two years. The IPCC approach, supported by environmentalists, economists, scientists, and other policy professionals worldwide, recognizes the following tasks yet to be completed:

- Reducing scientific and economic uncertainties to improve policymaking,

- Selecting domestic policies that respond to the scientific and economic information, and
- Developing fair, enforceable, and responsive multilateral agreements.

Enterprise for the Americas

One of the most innovative of recent global environmental proposals is contained in the Administration's Enterprise for the Americas initiative. This initiative will develop economic and trade relations with the nations of Latin America and the Caribbean, while at the same time addressing environmental protection. Under this innovative plan, the United States has proposed to spur debt-for-nature swaps, in which certain developing country debts owed to the United States are reduced and commitments of long-term natural resource conservation are made. The initiative also proposes creating environmental trust funds from interest on remaining debts made payable in local currency.[7] Latin American governments would use these trust funds, in cooperation with nongovernmental organizations, to carry out long-term projects designed to preserve and protect the environment.

U.N. 1992 Conference on Environment and Development

Another item on the nation's global environmental agenda is participation in the 1992 United Nations Conference on Environment and Development (UNCED '92), which will focus on the integration of global environmental and development issues. CEQ is charged with preparing the U.S. National Report to UNCED in 1991 and is also coordinating the involvement of the nongovernmental community through roundtable discussions, public hearings, and other preparations for the event.

Preventing Pollution

Since the early 1970s the United States has spent billions of dollars on pollution cleanup after the fact, often neglecting the wisdom that an ounce of prevention is worth a pound of cure. In 1990 the federal government enacted legislation and developed a national strategy to reorient the national environmental agenda away from the discharge end of the pipe toward preventing pollution before it starts. Pollution prevention increasingly is viewed as the preferred way to overcome the limitations of traditional pollution control.

Pollution prevention in its broadest sense results in a healthier quality of life and often healthier productivity and profits. The prevention approach aims for more efficient use of energy and materials through such activities as source reduction, recycling, organizational changes, and technological innovation. Companies that practice pollution prevention lower their costs for waste disposal, for compliance with regulation, and for litigation. Prevention makes particular sense under conditions of intense economic competition when every penny saved by focusing on a permanent, preventive solution goes directly to the bottom line.

Chapters 2 and 3 discuss the development of policies to prevent pollution in further detail. A few examples of the principle in action suffice here.

Clean Air Incentives

The Clean Air Act Amendments of 1990 employ a preventive approach to achieve rapid, cost-effective reductions of hazardous air pollutants. Under this provision, companies that voluntarily and permanently reduce hazardous air pollutants in advance of the legislated deadline may opt to postpone installation of maximum available control technology.

Oil Pollution Prevention

On the domestic front, Congress and the Executive Branch reached agreement on oil pollution legislation[8] with numerous prevention measures. The Oil Pollution Act of 1990 requires better planning and preparedness and measures to increase navigation safety, including new standards for vessel construction, crew licensing, and manning. The law also extends the liability of owners and operators of vessels and other facilities and strengthens the penalties for spills, creating a powerful incentive for all parties to prevent future accidents.

In the international arena, President Bush proposed in July 1989 negotiations for an international agreement to enhance cooperative oil spill prevention, preparedness, response, and research. In November 1990, 80 nations agreed to the International Convention on Oil Pollution Preparedness, Response and Cooperation.

Outreach

A key to successful pollution prevention is information-sharing, which raises awareness of the prevention movement and stimulates better technological, management, and accounting methods. Sharing such information can expand the pool of potential users. In 1990 Congress passed legislation to boost research and data collection on pollution prevention.[9] CEQ and EPA developed outreach and technical assistance programs involving corporations, trade associations, state and local governments, the news media, and the public.

S.C. Delaney, EPA

Environmental crimes now carry stiff penalties.

Vigorous Law Enforcement

A decade or more ago, environmental lawbreakers were not generally subject to severe penalties or aggressive enforcement activity. Today, law enforcement agencies at all levels of government are investigating and prosecuting environmental crimes in unprecedented numbers. New federal sentencing guidelines implemented in 1987 are having a deterrent effect as company executives more frequently face criminal penalties, including prison terms—a cost that cannot be passed on to consumers.

EPA has over 300 new enforcement staff members, and under legislation passed in 1990,[10] will add 200 more environmental investigators by 1995. In the past two years, the federal government levied record-high numbers of civil and administrative penalties for violations of statutes. Felony indictments in 1990 were 33 percent higher than in 1989; indictments and convictions in 1989 were 70 percent higher than those in 1988.

A Federal Environmental Almanac for 1989-1990

The previous section described the principles and offered examples of the Bush Administration's National Strategy for Environmental Quality. This section presents an alphabetized almanac of major environmental events of the past two years, many of which are putting those principles into action. In some cases, information presented in the foregoing section is repeated.

During the past two years, within the context of policies to promote economic growth, the nation recorded significant environmental progress. This progress included new legislation, improved programs and greater budgets, major international initiatives, and tougher environmental law enforcement. Business, environmental, and other nongovernmental groups worked cooperatively with each other and with the government to achieve their respective goals.

Some of these efforts were successful, while others still struggle toward their goals. But even incremental progress is cause for hope. Through trial, evaluation, correction, and persistence, the nation is forging a balanced and responsive environmental policy.

Agriculture

- **Farm Bill.** The 1990 Farm Bill included significant environmental initiatives. For the first time, the farm program authorization included a forestry title implementing the President's national tree planting initiative. The bill strengthened the anti-swampbuster program protecting wetlands by denying federal benefits to producers who grow crops on wetlands converted after 1985. It also extended the Conservation Reserve Program (CRP) that takes highly erodible cropland out of production for at least ten years. Within the CRP, the bill created a Wetland Reserve Program with easements of at least 30 years. The bill also authorized debt-for-nature exchange programs with Latin America; provided farmers with incentives to prevent pollution through long-term adoption of alternative farming methods; set national standards defining "organic" food; and required better recordkeeping of "restricted use" pesticides.

- **Low-Input Sustainable Agriculture.** A coordinated research initiative will provide the scientific basis for techniques to comprehensively reduce dependence on agricultural chemicals and enhance use of natural biological processes.

- **Pesticides.** The federal government is working on legislation that will improve food safety by streamlining regulations to allow faster removal of dangerous substances from the market and to speed approval of new, environmentally safe pest-control methods. An interagency effort by EPA, USDA, and the Food and Drug Administration (FDA) is increasing the data gathered on pesticide use and levels of pesticide residues in fresh fruits and vegetables to improve the reliability of risk assessments. EPA has blocked all sales, distribution, and use of Alar products labeled for use on food products and stepped up efforts against a range of other suspect pesticides. Efforts included blocking the sale of roughly 100 million apples that had been illegally treated with the fungicide Botran.

Air

- **Asbestos.** EPA announced a U.S. ban by 1997 on almost all new uses of asbestos, a carcinogen linked to lung and chest cancer. The agency also released a guidebook on asbestos that suggests removal is not always the best way to reduce potential exposure and health risks. The General Services Administration (GSA) furthered its existing program of managing asbestos in place, consistent with the new EPA guidebook.

- **Benzene.** EPA issued rules to reduce industrial emissions of the hazardous air pollutant benzene by 90 percent.

- **Clean Air Legislation.** The Clean Air Act Amendments of 1990 were the first major overhaul of federal air quality laws since 1977. Among many provisions, the amendments aim to accomplish the following goals:

    - Further reduce pollutants from automobiles and other sources that contribute to urban smog, which will help cities attain existing health-based air quality standards;

    - Require increased use of cleaner motor vehicle fuels;

    - Reduce emissions of hazardous air pollutants from industrial sources by 75 to 90 percent;

    - Achieve a permanent reduction in utility sulfur dioxide emissions of 10 million tons annually and restrain utility nitrogen oxide emissions; and

    - Phase out the production and use of ozone-depleting substances and assist developing nations in making the transition to safer substitutes.

- **Gasoline and Diesel.** EPA issued rules to lower gasoline volatility (which creates smog precursors) in summer months and issued rules to phase out 80 percent of the sulfur in diesel fuel by 1993.

- **Mercury.** Following research and collaboration among the Department of Health and Human Service's Centers for Disease Control, EPA, the National Paint and Coatings Association, and manufacturers of mercury compounds used in interior latex paint, EPA prohibited the use of mercury compounds in indoor paint.

- **Municipal Waste Combustors.** EPA proposed standards for municipal waste combustors to reduce overall air emissions from such sources by 90 percent.

- **Radon.** EPA released data showing high levels of naturally occurring radon gas in housing in certain areas of the country and undertook public education campaigns to urge Americans to test and safeguard their homes, schools, and businesses. GSA completed radon testing on all GSA-controlled buildings and is mitigating and retesting those buildings with radon above the EPA recommended-action level.

Budget

- **Funding Increases.** The fiscal 1991 budget continued a trend begun in fiscal 1989: significant reinvigoration of most federal environmental/conservation programs (see Table 1-1).

- **Priorities Report.** In September 1990 the EPA Science Advisory Board released a major report[11] suggesting ways to improve environmental policymaking. It compared disparate environmental problems according to the degree of risk they pose, not only risks to human health but also to the health of ecosystems. Given budget constraints in both the public and private sector, the report suggested principles to underlie a broader, more integrated, and more carefully targeted environmental policy.

Department of Defense

- **Chesapeake Bay Agreement.** In April 1990 the Department of Defense (DOD) and EPA signed an agreement to combine efforts toward restoration of the Chesapeake Bay. DOD manages 65 major installations that comprise roughly

Table 1-1.—U.S. Budget for major environmental initiatives, 1989–1991.

SUMMARY OF MAJOR INITIATIVES	ACTUAL 1989	ACTUAL 1990	ENACTED 1991
	million $		
America the Beautiful	363	411	659
Land acquisition	206	237	342
Reforestation	—	—	70
Resource protection/recreation:			
Department of the Interior	157	174	247
Legacy '99: DOI	517	563	819
Maintenance	347	373	435
Rehabilitation	50	84	221
Dam safety	78	62	104
Cleanup	42	44	59
Protecting America's wetlands*	201	283	299
Department of the Interior	94	126	181
Department of Agriculture	79	128	107
Environmental Protection Agency	9	13	22
Army Corps of Engineers	98	124	150
National Oceanic & Atmospheric Adm.	15	18	20
EPA operating budget	1,752	1,938	2,313
Superfund	1,410	1,530	1,616
Cleanup	532	651	753
Enforcement	176	187	209
Support	702	692	654
Federal facility cleanup:			
Department of Energy	1,762	2,354	**3,687
Department of Defense	1,155	1,282	1,923
Other agencies	107	147	172
Global change research	—	659	954
Natural resources research	680	710	844
Total	7,947	9,877	13,287

*Total adjusted to eliminate double counting of DOI Wetlands already included in America the Beautiful, wetlands, Coastal America, and global change research in EPA operating budget.

**Includes a proposed $340 million 1991 supplemental for environmental restoration and waste management.

Source: Executive Office of the President, Office of Management and Budget, *Budget of U.S. Government*, (Washington, DC: U.S. Government Printing Office, 1991).

350,000 acres within the Chesapeake Bay watershed. A major feature of the agreement provides that DOD will achieve significant compliance with existing Clean Water Act discharge permits or seek compliance agreements with EPA.

- **Defense and the Environment Initiative.** DOD adopted a five-point initiative in environmental compliance and protection. The department sponsored a September 1990 conference for public and private leaders to discuss a long-term strategy and near-term DOD environmental action plan, an enhanced DOD environmental decisionmaking structure, and ways global strategic policy might encompass environmental challenges.

- **Research and Development.** Defense legislation[12] signed by the President in 1990 created a $150 million Strategic Environmental Research and Development Program (SERDP) aimed at enhanced environmental data gathering and analysis, promotion of compliance activities, and development of advanced energy and cleanup technologies.

Education

- **Earth Day.** CEQ coordinated actions by federal departments and agencies to celebrate the twentieth anniversary of Earth Day, including an exhibition on the Mall in Washington, D.C., and activities by federal agencies throughout the country. Some agencies used the opportunity to kick off awareness-raising special programs that continue today, such as recycling programs and awards for grass-roots involvement.

- **Environmental Literacy.** In partnership with the 50 state governors, the President announced national education goals in six areas, three of which have particular relevance to the environment: student achievement and citizenship, math and science, and adult literacy and lifelong learning.

  The following federal initiatives exemplify a strong commitment to greater environmental literacy:

  - In November 1990 EPA and the Department of Energy (DOE) signed a memorandum of understanding to encourage students to pursue careers in environment- and energy-related technical fields.

  - An annual EPA Environmental Youth Awards Program encourages environmental citizenship by elementary and secondary students.

  - The National Environmental Education Act[13] directs EPA to improve basic science literacy in grades K-12 and colleges and to stimulate creativity at the local level through grants, awards, and training programs. The act authorizes presidential awards to teachers for excellence in environmental education.

  - Under the National Parks as Learning Laboratories program, the National Park Service in the Department of the Interior (DOI) is identifying "mentor parks" with outstanding education programs to share their successes with other parks. Courses on curriculum and skills development are being offered to field personnel.

EARTH DAY
1990
WASHINGTON
D.C.

S.C. Delaney, EPA

Among the Earth Day 1990 celebrations was this one held on the Mall in Washington, D.C.

- As part of the Take Pride in America program, DOI has developed elementary school environmental science curriculum guides and other educational resources, such as a Mark Trail coloring book for preschool and elementary school children.

- The Fish and Wildlife Service (FWS) in the Department of the Interior has produced a newspaper on the conservation of wetlands and waterfowl and distributed it to over 390,000 school children. FWS also developed and published the Federal Junior Duck Stamp Program bibliography for use in K-12 classrooms.

- EPA works with historically black colleges and universities to develop environmental education programs and is developing a predoctoral training program for science and engineering students interested in the Resource Conservation and Recovery Act (RCRA).

- EPA and the National Guard are working together to involve the urban poor in local environmental improvement projects.

- In the field of medical education, as required by law, the Department of Health and Human Services (DHHS) completed the development of "Case Studies in Environmental Medicine" for use by physicians. Over 30,000 pediatricians received the Case Study on Lead in the Environment.

Energy

- **Clean Coal Technology.** Congress has authorized funding to complete a $2.5 billion Clean Coal Technology program, administered by the Department of Energy (DOE). Over the next 10 to 15 years, new coal-burning technologies will become available that reduce air pollution and improve energy efficiency.

- **Energy Efficiency.** In advance of the release of the National Energy Strategy (see below), DOE announced 11 initiatives in January 1990 in energy efficiency and renewables: awarding contracts to retrofit federal buildings with more efficient lighting; accelerating research and development in photovoltaics and in alternative transportation fuels made from nonfood biomass feedstocks; issuing final national energy standards for washing machines, dryers, and dishwashers; preparing regulatory and legislative proposals to stimulate efficiency improvements in the utility, commercial, and construction sectors; expanding an industrial energy audits program for medium-sized manufacturing plants; and using the government-industry technology transfer process to speed more efficient technologies into widespread use. With respect to energy-efficient federal buildings, the General Services Administration spent $10 million in fiscal 1990 on energy retrofit projects, and $30 million is earmarked for such projects in fiscal 1991.

- **National Energy Strategy.** DOE analyzed numerous options and developed a National Energy Strategy (NES) that addresses environmental and safety concerns along with other national needs. With regard to air quality, the NES seeks to reduce energy-related emissions to achieve Clean Air Act requirements and other air quality concerns. The strategy includes responses to potential climate change such as enhanced energy conservation and efficiency, accelerated development of alternative and renewable energy sources, and expanded efforts to ensure nuclear power safety and future growth in nuclear power.

In waste management, the NES seeks to develop technologies, procedures, and safeguards to ensure that wastes are minimized wherever possible and, in all cases, treated, stored, and disposed of in a manner that protects human health and the environment. The NES aims to increase the productive use of municipal waste through waste-to-energy applications.

Concerning water and land use, the NES seeks to ensure that activities associated with energy production and use protect surface waters and groundwater. It also would improve procedures for incorporating environmental concerns into energy facility siting and land use.

- **NEPA and DOE.** DOE developed rules to centralize and strengthen compliance with the National Environmental Policy Act (NEPA).

- **Offshore Oil and Gas Development Moratorium.** In a June 1990 package of decisions recognizing the importance of both environmental concerns and domestic oil and gas supplies, the President postponed for at least ten years offshore oil and gas lease sales in selected areas, pending further studies concerning the environmental and resource characteristics of the areas. The tracts affected comprise 99 percent of the California coast, the coasts of Oregon and Washington state, the southwest coast of Florida, and the Georges Bank area off New England. Lease sales near Santa Barbara, California, may proceed after January 1, 1996, but only after further studies of the environmental and resource characteristics of these areas as recommended by the National Academy of Sciences. At the same time, the President endorsed continued oil and gas activities in the Gulf of Mexico and parts of the Atlantic and Alaskan coasts.

  The Oil Pollution Act of 1990 placed a limited moratorium on lease sales on the Outer Banks area off the coast of North Carolina.

- **Oil Supply and Demand.** In response to Iraq's invasion of Kuwait, DOE developed a set of short- and long-term responses with emphasis on such supply measures and demand restraints as electricity and oil conservation, increased federal energy efficiency, and accelerated conversion of the federal vehicle fleet to alternative fuels. The benefits of demand-side measures accrue both to national energy security and the environment.

Enforcement

- **Clean Water Act.** The Department of Justice (DOJ) and EPA achieved a record-high civil penalty for violations of the Clean Water Act by negotiating a settlement with Shell Oil Co. for $19.7 million in fines and damages for a 400,000-gallon oil spill near San Francisco.

  Civil and administrative actions were pressed against 61 cities (including Detroit, El Paso, Phoenix, and San Antonio) for violations of the Clean Water Act.

  Enhanced criminal enforcement and highly publicized tough sentences for those who illegally fill wetlands is proving to be an effective deterrent to wetlands loss.

  DOJ and EPA took the first broad ecosystem approach to enforcement by charging 26 facilities in the Chesapeake Bay watershed with violations of the Clean Water Act. They also filed three civil cases focusing on pollution in the Grand Calumet River, Indiana, which flows into Lake Michigan.

  DOJ brought action against the South Florida Water Management District and the Florida Department of Environmental Regulations (DER), seeking a judgment that the District and DER have failed to protect Everglades National Park and Loxahatchee National Wildlife Refuge from water pollution caused by the Everglades Agricultural Area. DOJ negotiated major settlements for natural resource damages, including a $66-million settlement for cleanup of PCB contamination and restoration in New Bedford Harbor, Massachusetts.

- **Exxon Valdez Oil Spill.** DOJ obtained an indictment against the Exxon Corporation and Exxon Shipping on a total of ten felony and misdemeanor counts arising from the largest oil spill in U.S. history, which occurred in Prince William Sound, Alaska.

- **Hazardous Substances.** DOJ successfully prosecuted intentional violators of hazardous waste laws, including a waste hauler who was convicted of unlawful disposal and sentenced to three-and-a-half years in jail. In another case, a company owner was sentenced to three years of jail time for unpermitted treatment, storage, and disposal of hazardous wastes. The Department of Justice brought civil lawsuits against 34 companies and individuals to halt violations concerning the safe demolition and renovation of buildings containing asbestos. DOJ proposed fines totaling $1.65 million for 42 companies that failed to report toxic chemical discharges as required by law. And the Syntex Corporation and others were ordered to cleanup dioxin contamination in Times Beach, Missouri.

- **Largest Settlement.** DOJ obtained the largest single settlement amount ever in a suit by the United States against one entity for violation of a federal environmental statute. Texas Eastern Transmission Corp. paid a $15-million penalty and agreed to perform cleanup work estimated to cost $400 million at 89 sites located in 14 states.

- **Ozone Layer Protection.** EPA initiated cases to block illegal importation of chlorofluorocarbons and initiated landmark efforts to enforce compliance with international agreements phasing out the production and use of ozone-depleting substances.

- **Resources and Results.** Over 300 new enforcement staff have been added at EPA, and the President signed legislation to hire 200 investigators by 1995. The DOJ environmental enforcement budget is up 65 percent since fiscal 1989.

  Since establishing an Environmental Crimes Unit eight years ago, DOJ has indicted 703 corporations and individuals, with nearly one-third of DOJ indictments and convictions occurring in the last two years. Environmental indictments and convictions showed a 70-percent increase in 1989 over 1988, and felony indictments in 1990 climbed 33 percent over the previous year. In 1990 DOJ achieved a 95-percent conviction rate, and prison sentences averaged a record 1.8 years, with the longest sentence being for 12 years. DOJ and EPA levied record-high numbers of civil and administrative penalties for violations of EPA-administered statutes, with fines totaling $35 million in 1989. In 1990 DOJ marked the second straight billion-dollar recovery year for civil enforcement.

- **Solid Waste.** The largest civil judicial penalty ever assessed for violation of the Resource Conservation and Recovery Act (RCRA)—nearly $2.8 million—was upheld by a federal appeals court. The court permanently prohibited operation of a privately operated landfill in northern Indiana and ordered the company to conduct corrective action.

Federal Facilities

- **Accelerated Cleanup.** For over 40 years, the federal government has failed to manage adequately and dispose properly the wastes it generates at various sites around the country. In the past two years, a major shift has occurred toward reversing this legacy. For example, DOE's fiscal 1991 appropriations provide $530 million for nondefense cleanups and $2.8 billion for defense-related cleanups. EPA negotiated over 50 cleanup agreements with federal agencies in fiscal 1990.

- **Public Health Assessments.** DHHS entered into memoranda of understanding with DOD and DOE to undertake public health assessments of federal facilities on the Superfund National Priorities List.

Hazardous and Solid Wastes

- **International Shipments of Waste.** The United States helped negotiate and was a signatory to the Basel Convention negotiated under the auspices of the United Nations Environment Program to control international hazardous waste shipments. The United States worked to develop domestic laws and regulations to implement the Basel Convention but, in the meantime, established a policy requiring bilateral agreements with nations accepting U.S. waste exports to ensure waste is disposed of in an environmentally sound manner.

- **Medical Waste.** As required by law, DHHS completed a comprehensive report on the public health impact of medical waste. The study found that such pollution presents a very small risk to the general population in terms of AIDS and hepatitis B transmission, but specific occupational groups are at increased risk of cuts, punctures, and mechanical trauma associated with the handling of medical waste.

- **Resource Conservation and Recovery Act.** EPA issued a report on the Resource Conservation and Recovery Act (RCRA)[14] setting priorities and directions to improve implementation of solid waste disposal.

- **Recycling.** EPA has adopted goals to reduce municipal solid waste nationwide through a combination of source reduction and recycling measures. The federal government has issued guidelines encouraging federal procurement of products made of recycled materials. The Recycling Advisory Council, a joint project of the National Recycling Coalition and EPA, is focusing on the development of markets for secondary materials. In conjunction with Earth Day 1990, many federal agencies began in-house recycling efforts, including the Executive Office of the President. GSA instituted a number of changes in its Interagency Fleet Management System, including recycling used motor oil, expanded use of retread tires, more use of remanufactured parts, recycling of used aluminum license plates, and endorsing the use of commercial vendors that use recycling equipment for work involving CFCs.

- **Superfund.** In 1989 EPA exceeded Congressional targets for Superfund cleanup starts and site studies. The agency has reoriented the Superfund hazardous waste site cleanup to an enforcement-first program that requires more parties responsible for the pollution to undertake cleanups. In fiscal 1989 and 1990, the enforcement program collected twice as much money in injunctive relief and cost recovery than in the entire previous history of the program ($1 billion in 1989 alone). The program filed 252 Superfund cleanup suits—more than in the first six years of the program. In fiscal 1989 and 1990, DHHS increased the number of Superfund sites receiving public health assessments to 1,300.

International Initiatives

- **African Elephants.** In June 1989 the United States banned imports of African elephant ivory, an action that sparked other nations to follow suit and led to international action under the Convention on International Threatened and Endangered Species (CITES) to list the African elephant as endangered. The United States is providing assistance to African nations in the conservation of this species.

- **Antarctica.** Legislation signed by the President in 1990 places an indefinite prohibition on any U.S. mineral resource exploration and development in Antarctica.[15] The law is consistent with U.S. support for a stronger environmental protection agreement to supplement the existing Antarctic Treaty.

- **Biodiversity.** The United States is participating in negotiations aimed at developing a convention on preservation of global biological diversity.

- **Canada.** The United States and Canada, which enjoy wide-ranging, cooperative, and ongoing relations in environmental matters, conducted negotiations on an air quality accord. The agreement will provide a framework for addressing acid rain and other mutual air pollution concerns.

- **Development and Investment.** The United States endorsed the establishment of the Global Environment Facility in the World Bank, a three-year pilot project to finance the incremental costs of development projects that have global environmental benefits. President Bush supported and signed legislation[16] to condition U.S. support for multilateral development bank projects on the implementation of procedures to assess their environmental impacts. The United States helped negotiate and was a signatory to an international agreement to create the European Bank for Reconstruction and Development to promote environmentally sustainable development in Eastern Europe. The Overseas Private Investment Corporation (OPIC) facilitated the creation of a $100-million Environmental Investment Fund to support new or expanding business enterprises in developing countries that practice sound environmental management. OPIC will contribute up to $40 million to the privately managed fund, and the remaining $60 million will be raised through the sale of limited partnership interests.

- **Eastern Europe.** During a 1989 trip to Eastern Europe, President Bush offered to emerging democratic nations financial and technical aid, help in drafting environmental laws and regulations, and access to pollution control technology. Following up on the President's offer, EPA provided support to establish the East European Environmental Center in Budapest, Hungary, which opened in September 1990. The United States is also helping to develop programs to improve air and water quality in Krakow, Poland.

- **EPA-Cabinet Legislation.** President Bush endorsed the concept of elevating EPA to Cabinet status. If enacted, such a proposal would, among other things, give the EPA Administrator commensurate status with counterparts from other nations. The plan would also supplement EPA's authority to give U.S. technical assistance to foreign environmental programs. In 1989 the head of the EPA International Activities Office was elevated to the assistant administrator level and made a presidential appointment.

- **Extraterritorial Impacts of U.S. Activities.** A task force chaired by CEQ is examining Executive Order #12114, related to environmental assessment of extraterritorial impacts of U.S. government activities.

- **Global Climate Change.** The Secretary of State's first major address in January 1989 expressed the President's intention to take action in the area of global climate change. In February 1990 the President addressed the U.N.-sponsored Intergovernmental Panel on Climate Change (IPCC), the leading global forum for climate change science and policy analysis. The United States participates actively in IPCC, has hosted IPCC plenary sessions and workshops, and chairs the IPCC Response Strategies Working Group. U.S. policy is consistent with the findings of the IPCC First Assessment, a

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The United States provided support to establish the East European Environmental Center in Budapest, Hungary.

report on the scientific evidence, potential impacts, and policy options related to global climate change, released in September 1990.

At the Malta summit with Soviet President Gorbachev, President Bush announced two initiatives on global climate change. The first, the White House Conference on Science and Economics Research Related to Global Change, was held April 17-18, 1990, and drew together experts on science, economics, and the environment from 18 nations and two multilateral institutions to address ways to increase understanding of climate change issues. The second initiative was a U.S. offer to host the first session of U.N. negotiations toward a multilateral framework convention on climate change. The latter meeting was held February 4-14, 1991, in Chantilly, Virginia. The U.S. supports completion of the framework convention in time for its signing at the U.N. Conference on Environment and Development in the summer of 1992.

The United States supports a comprehensive approach to the issue that

- Considers all sources and sinks of greenhouse gases,
- Addresses adaptation strategies as well as emissions levels,

- Includes as many nations as possible,
- Considers the financial and technical realities in all nations, and
- Allows for the use of market-based, innovative, adaptible, and economically efficient responses.

The following actions, being taken pursuant to the U.S. Climate Change Strategy, will result in U.S. greenhouse gases in the year 2000 being equal to or below the 1987 level:

- Eliminating stratospheric ozone-depleting compounds which are also strong greenhouse gases,
- Directly controlling various greenhouse gases and their precursors,
- Reducing utility and other industrial emissions in a way that strongly encourages energy efficiency,
- Increasing forest greenhouse gas sinks,
- Encouraging energy efficiency in such areas as buildings, appliances, and lighting, and
- Increasing the use of renewable and nonfossil sources of energy.

Such actions are being implemented through the Clean Air Act Amendments of 1990, the National Energy Strategy, the America the Beautiful reforestation campaign, and the London Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer. Each of these efforts displayed U.S. leadership in global environmental protection.

■ **Global Environmental Research.** Integral to the U.S. Climate Change Strategy is the world's largest program of research and development. This coordinated program includes *in-situ* and theoretical studies of physical, chemical, biological, and geological processes, as well as a space-based Earth Observing System, the "Mission to Planet Earth." Congress appropriated $954 million in fiscal 1991 for the U.S. Global Change Research Program, and for fiscal 1992 the Administration is requesting almost $1.2 billion—twice the fiscal 1990 level. Indeed, the United States provides about 50 percent of the financial resources for the total international research program. New legislation[17] endorses the U.S. research program by codifying the interagency Committee on Earth and Environmental Sciences (CEES) that oversees it.

- **Latin America and Caribbean.** Under the Enterprise for the Americas Initiative, the United States is developing economic and trade relations with the nations of Latin America and the Caribbean, while at the same time addressing environmental protection. Among the U.S. proposals are debt-for-nature swaps and trust funds created to support long-term environmental programs in Latin American nations. Also, DHHS provided technical information and assistance to the Pan American Health Organization for assessing effects of hazardous waste on public health.

- **Marine Resources.** The United States was instrumental in passage of a United Nations resolution recommending a moratorium by 1992 on driftnet fisheries. The United States reached agreement with Japan, Taiwan, and Korea on programs for monitoring the adverse effects of high seas driftnet fishing, such as the incidental take of seabirds, seals, and dolphins. The U.S. government also began negotiations with a number of countries on establishing programs to minimize the incidental take of dolphins and sea turtles in regional fisheries of the eastern Pacific Ocean and the Caribbean.

- **Mexico.** Under the auspices of a 1989 agreement, the United States and Mexico are conducting a four-year study of Mexico City air quality and measures for its improvement. The two nations focused on the environment during the last two summits between President Bush and President Salinas and in the 1989 and 1990 U.S.-Mexican Bi-National Commission meetings. In 1990 the two nations agreed to take joint action to improve water quality in southern California and the Tijuana area.

- **Ozone Layer Protection.** To prevent ozone layer depletion and eliminate one category of greenhouse gases, the United States proposed to phase out most uses of ozone-depleting substances by the year 2000. The United States led international efforts culminating in the 1990 London Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer. A group of nations including the United States will provide financial and technical assistance to help developing countries make the transition to non-CFC technologies. The Clean Air Act Amendments of 1990 placed the United States on an accelerated schedule for the CFC phaseout. In fiscal 1990 the Justice Department brought landmark actions to enforce the CFC agreement.

- **Peace Corps.** In 1990 Peace Corps volunteers received environmental training in water pollution prevention, waste disposal, pesticide management, and reforestation.

- **Pesticides.** The United States supported adoption of international guidelines which provide that banned or severely restricted pesticides should not be exported without the prior informed consent of the importing country. This approach is in effect for U.S. exports.

- **Summitry.** President Bush supported efforts to make the environment a major focus of the annual "G-7" summits of industrial nations in Paris in July 1989 and in Houston in July 1990. In Houston, the President called for the negotiation, by mid-1992, of a global forestry agreement to address myriad issues of deforestation and reforestation. At a gathering of world leaders in Tokyo in February 1989, the President held meetings with leaders of Japan and Brazil and discussed the rapid depletion of tropical rainforests. In Washington in June 1990, President Bush and President Gorbachev signed a new agreement expanding environmental cooperation.

- **Technology Transfer.** While the United States employs some of the world's most advanced technologies for pollution prevention and emissions control, the government and private sector only recently have begun a coordinated effort to develop global markets for these goods and services. An EPA advisory board on international environmental technology transfer investigated the problem and issued recommendations in late 1990. U.S. technology transfer to developing nations was also addressed as part of the 1990 London accord on ozone depletion and the creation of an environmental facility within the World Bank.

- **United Nations 1992 Conference.** The United States is active in planning the 1992 United Nations Conference on Environment and Development, and has urged that global climate and forestry agreements be completed for signing, if possible, at that conference.

- **U.S.S.R.** Senior U.S. and Soviet officials have met to expand cooperation in environmental matters, including plans for linked international parks in the Bering Sea wilderness; marine mammal and fisheries conservation; and joint projects related to marine pollution, environmental law, wetlands, nuclear waste cleanup, and radiation monitoring.

- **Waste Shipments.** The United States helped develop and was a signatory to the Basel Convention, which governs transboundary shipments of hazardous wastes in an environmentally sound manner.

- **Whaling.** With strong U.S. support, the five-year-old moratorium on commercial whaling was upheld in 1990 by the International Whaling Commission.

Pollution Prevention

- **Clean Air.** The Clean Air Act Amendments of 1990 allow companies that voluntarily and permanently reduce hazardous air pollutants in advance of the legislated deadline the option of postponing installation of maximum available control technology.

- **Clean Water.** EPA has launched a nationwide early warning system to help prevent municipal sewage treatment plants from violating Clean Water Act standards.

- **Grants.** EPA has set aside 2 percent of each of its program budgets for fiscal 1991 to fund pollution prevention demonstration projects. In 1990 EPA awarded 25 grants worth a total of $7 million to 23 states to boost development of pollution prevention projects; in 1989 the agency awarded 14 grants worth $4 million.

- **Legislation.** Congress enacted the Pollution Prevention Act of 1990, establishing a waste management hierarchy with preference given to source reduction. The act also required EPA to advance industrial pollution prevention by identifying measurable goals, improving data and measurement, offering grants to states, and establishing awards programs.

- **National Strategy.** In consultation with numerous parties, EPA developed and adopted a National Pollution Prevention Strategy. The strategy provides direction within the agency to reorient existing programs and targets specific chemicals from the manufacturing sector for voluntary prevention programs. The goal is to reduce national emissions of these chemicals 33 percent by the end of 1992 and at least 50 percent by the end of 1995.

- **Outreach.** EPA and CEQ have outreach programs that are promoting pollution prevention among industry and private groups. For example, in June 1990 EPA cosponsored an international conference to promote technical approaches to reducing the volume of solid and hazardous waste.

Public Lands

- **America the Beautiful.** The America the Beautiful initiative aims to protect, preserve, and expand America's national treasury of parks, forests, wildlife refuges, and other public lands. As one component of the initiative, the Department of the Interior (DOI) and the Department of Agriculture (USDA) are acquiring new federal lands with significant environmental or recreation value. Funding under the Land and Water Conservation Fund increased from $171 million in fiscal 1988 to $342 million by fiscal 1991. Another component of the initiative will increase the number of boat ramps, campsites, trails, and interpretive centers for America's growing population of outdoor enthusiasts and improve access for disabled Americans. Legacy '99 is a complementary DOI program to upgrade conditions at national parks, wildlife refuges, and other public lands by the end of the decade.

  In yet another facet of America the Beautiful, the President's Tree Planting Initiative is establishing a long-term reforestation program to plant and maintain one billion new trees annually for at least ten years. In the first-ever forestry title to omnibus farm legislation, Congress authorized a one-time grant to the private, nonprofit National Tree Trust Foundation, to leverage nonfederal funds and activities for the tree planting program. The foundation will help support the efforts of community tree planting groups and encourage Americans to directly participate in tree planting activities. The legislation also authorizes the USDA Forest Service to work with state and local governments, land grant universities, and the private sector to improve the management of private forests and those in urban areas.

- **Forest Service Resources Planning.** The 1990 Resources Planning Act (RPA) program[18] for the USDA Forest Service renews the agency's commitment to multiple-use management, which aims at conserving and wisely using resources to assure a healthy environment and a continuous supply of natural resources. In particular, the Forest Service has identified four priorities in coming years: enhanced recreation, wildlife, and fisheries resources; ecologically sensitive commodity production practices; improved scientific knowledge; and responses to global resource issues.

- **Rangeland Resources.** The DOI/Bureau of Land Management (BLM), the federal government's largest landowner, has adopted a long-term strategy to improve the public rangelands called "The Range of Our Vision." The strategy sets goals through the year 2009 to enhance rangeland environments while continuing to assist local economies that depend on the range. Activities include the improvement of rangeland riparian habitats; enhanced monitoring activities to ensure proper use of the range; completion of projects to enhance watersheds and reduce pollutants; and cooperation with nonfederal organizations for such improvements as revegetation, stream bank protection, and water development.

- **Recreation 2000.** The BLM Recreation 2000 initiative is a multiyear program to increase public opportunities to experience the variety of recreational resources on the public lands. Activities include upgrading facilities, improving public access, and managing outstanding natural areas as well as designated wild and scenic rivers. BLM and the Forest Service adopted a National Recreational Fisheries Policy to promote and enhance fishing opportunities on the lands they manage.

  Other BLM recreation-related efforts include the Back Country Byways program, which designates scenic drives and encourages local tourism, and Adventures in the Past, which aims at increasing public awareness of cultural resources on public lands and the need to protect them. All federal recreation-related programs depend on substantial partnerships with voluntary organizations, the private sector, and state and local governments.

- **Tongass National Forest.** In November 1990 Congress and the Executive Branch ended a decade-long debate over forest management in Tongass National Forest in Alaska. Legislation signed by the President[19] repealed a $40-million annual appropriation established in 1980 for the required harvest of 4.5 billion board feet of timber per decade. The new legislation directed the Forest Service to attempt to meet market demand and did not specify the amount of timber or guarantee an appropriation. The legislation retained long-term timber sale contracts with two pulp companies but required modification of the contract terms and a government study to determine the capability of the government to fulfill the contract requirements in view of the new legislation.

  Other provisions of the act withdrew from logging roughly one million acres, nearly 300,000 of which were designated as wilderness, and established 100-foot-wide no-logging buffer strips along both sides of major salmon streams.

- **Wilderness.** A tripling of wilderness designations on BLM land was included in a bill enacted in November 1990.[20] The act provides for 39 new wilderness areas in Arizona comprising about 1.1 million acres on BLM land and 1.3 million acres on land managed by DOI/Fish and Wildlife Service (FWS).

Among the new wilderness areas are lands in the Mohave and Sonoran deserts in western Arizona and in the Cabeza Prieta, Kofa, Imperial, and Havasu wildlife refuges. The 20,900-acre Gila Box in southeastern Arizona is designated as a Riparian National Conservation Area, the fifth such area in the country. The act releases back to multiple use 947,200 acres of BLM land that had been in wilderness study status. It also provided for ten other legislative provisions unrelated to Arizona wilderness, from designating 20.5 miles of the Clarks Fork River in northwestern Wyoming as a segment of the Federal Wild and Scenic River System, to authorizing the "Take Pride in America" public lands appreciation program.

In December 1989 a Nevada Wilderness Act[21] provided for 733,400 acres of wilderness in national forest areas throughout Nevada. The act also released 2.4 million acres of land formerly in study status back to multiple purpose use.

In the past two years, wilderness designated areas have received special attention regarding increased surveillance and patrols to deter or stop improper land use, coordination with local governments and law enforcement agencies, public education, and projects to maintain trails, protect archaeological sites, and improve water quality.

BLM is also completing nine statewide studies of potential wilderness areas to provide recommendations in 1991 for additional designations.

Transportation

The Department of Transportation issued a National Transportation Policy Statement in March 1990, emphasizing environmental protection and quality of life as one of six key themes. The policy set forth several objectives, including helping to meet requirements of the Clean Air Act Amendments of 1990, reducing aircraft noise, protecting wetlands and other natural resources, designing transportation systems that fit harmoniously into communities and ecosystems, promoting energy conservation, and preventing and improving response to oil spills.

■ **Alternative Fuels.** An innovative item in the Clean Air Act Amendments creates a pilot program for the production and marketing of alternative-fuel vehicles in California. The amendments also require the use of cleaner, reformulated gasoline in the nine U.S. cities with the worst ozone pollution.

In 1990 the National Highway Traffic Safety Administration in DOT implemented a provision of the Alternative Motor Fuels Act of 1988 that allows automakers, beginning in model year 1993, to earn extra credits under the Corporate

S.C. Delaney, EPA

The March 1990 National Transportation Policy Statement addressed traffic-related objectives including clean air requirements, transportation system design, energy conservation, and noise.

Average Fuel Economy (CAFE) program for vehicles that are "dual-fuel" (run on both petroleum fuels and alternatives such as compressed natural gas or methanol).

In accordance with the Alternative Motor Fuels Act and in conjunction with DOE, the General Services Administration (GSA) purchased 65 dual-fuel vehicles for its Interagency Fleet Management System in Detroit, Los Angeles, San Diego, and Washington, D.C. GSA solicited for up to 200 natural gas-powered vehicles and anticipates that even more alternative-fuel vehicles will be acquired in the future.

- **Auto Fuel Efficiency.** In 1990 GSA continued an ongoing program to upgrade its motor vehicle fleet, resulting in a more fuel efficient fleet as well as a much higher percentage of vehicles meeting the newer emission standards.

- **Aviation Noise.** New legislation[22] directs DOT to prepare a national aviation noise policy, including provisions to phase out the noisiest aircraft currently in operation by the end of 1999.

- **Highway Programs.** The Federal Highway Administration (FHWA) issued an environmental policy statement to further develop the National Transportation Policy for the federal-aid highway program. In cooperation with the American Association of State Highway and Transportation Officials, the

FHWA held a conference on Highways and the Environment in November 1990 for national and state highway and environmental officials. That same month, a conference of regional officials of FHWA, EPA, and the Army Corps of Engineers met to discuss wetlands and permits issues. The conference improved working relationships, reviewed wetlands law, and discussed better integration of transportation programs with the environmental impact statement process (see Chapter 5 for a fuller discussion of NEPA integration issues).

Water

- **Coastal Barrier Protection.** New legislation[23] almost tripled the size of the Coastal Barrier Resource System to over 1.25 million acres encompassing 1,211 miles of shoreline along the Atlantic Ocean, Gulf of Mexico, and Great Lakes. The act limits federal spending and assistance for development within designated coastal barrier areas.

- **Great Lakes.** The Great Lakes Critical Programs Act of 1990[24] provided tools for the cleanup of the Great Lakes in cooperation with the government of Canada.

- **Marine Sanctuaries.** In November 1990 the President signed legislation designating 2,600 square nautical miles of coastal waters off the Florida Keys as the nation's ninth national marine sanctuary. Work is proceeding on additional designations, including Monterey Bay in California.

- **Medical Wastes on Beaches.** To address the problem of medical wastes washing up on beaches, EPA is conducting a pilot medical waste tracking system to serve as a model for further action. The system involves Connecticut, Louisiana, New Jersey, New York, and Rhode Island, as well as the District of Columbia and Puerto Rico.

- **Ocean Dumping.** EPA secured consent agreements with local jurisdictions to phase out ocean dumping of sewage sludge by June 1992. The President proposed legislation to require criminal felony penalties for illegal ocean dumping, and the U.S. Attorney General created a SWAT Team on Ocean Pollution to coordinate enforcement and share information with state and local officials.

- **Offshore Development.** As part of a June 1990 package of decisions related to offshore oil and gas development, the President directed immediate action to reduce the possibility of offshore oil spills by redirecting tanker traffic away from sensitive areas such as the Florida Keys and Everglades and to improve the ability of industry and government to respond to oil spills.

- **Oil Pollution—*Exxon Valdez*.** The Vice President and several interagency teams assessed the spill, and DOT supervised the cleanup by Exxon. EPA is coordinating an interagency task force on long-range restoration of Prince William Sound. The natural resource trustees (representatives of DOI, NOAA, USDA, and the State of Alaska) are conducting an assessment of natural resource damages in preparation for civil litigation against Exxon to recover damages. DOJ obtained an indictment against the Exxon Corporation and Exxon Shipping on a total of ten felony and misdemeanor counts arising from the spill. A federal court denied both defendants' motions to dismiss the indictment, and the case was set for trial in April 1991.

- **Oil Pollution—International Cooperation.** At the June 1989 summit in Paris, the President proposed to negotiate an international agreement to enhance cooperative oil spill prevention, preparedness, response, and research. The leaders of other nations agreed, and in November 1990, the United States and 79 other nations adopted an International Convention on Oil Pollution Preparedness, Response, and Cooperation. The convention requires establishment of response plans by nations and by owners of ships and waterfront and offshore facilities. It provides for sharing technical support and equipment among parties to the treaty and for sharing results of pollution response research activities.

- **Oil Pollution—New Legislation.** As with the Clean Air Act Amendments, a May 1989 proposal by the President to strengthen oil pollution liability and compensation laws helped break a Congressional deadlock that had continued for over a decade. In August 1990 the President signed oil pollution legislation[25] that creates a $1 billion cleanup trust fund. The law also establishes measures to improve prevention, response, containment, and recovery, and it increases federal coordination and enforcement.

- **Research.** The Department of the Interior (DOI) began a $6-million three-year joint project with the American Petroleum Institute to research and develop new cleanup technology. The DOI/Minerals Management Service joined with the U.S. Navy to reactivate an oil spill research facility in Leonardo, New Jersey.

- **Water Projects.** The federal government is seeking termination of uneconomic and environmentally damaging projects such as the Garrison Diversion Unit in North Dakota. EPA reviewed and denied construction permits for the Two Forks Dam in Colorado. The agency also rejected the proposed Big River reservoir project in Rhode Island, based on unacceptable potential effects on wetlands, wildlife, and recreation.

  The DOI/Bureau of Reclamation is mitigating adverse impacts of large water projects already constructed, and an environmental impact statement (EIS) is being prepared for operations at Glen Canyon Dam in Arizona. DOI has announced a plan to balance water usage and environmental protection in the Central Valley of California, including preparation of an EIS. The department is renewing long-term water contracts with the understanding that adjustments may be required when the EIS is completed.

- **Water Quality.** Beginning in fiscal 1990, the President requested and Congress approved increased funding for a coordinated Water Quality Initiative (WQI), involving the Departments of Agriculture, Interior, and Commerce and the Environmental Protection Agency. For example, under the WQI, the Department of Agriculure initiated a national groundwater quality program involving research and promotion of economically viable crop-production systems that reduce the risk of groundwater contamination in critical problem areas. In 1990 USDA initiated 85 projects. The U.S. Geological Survey in the Department of the Interior supported the WQI through its National Water Quality Assessment program, which is developing more effective ways to assess the status, trends, and causes of water quality conditions at 60 study units nationwide.

  EPA proposed new rules to regulate 26 pesticides and 36 other contaminants in drinking water. These rules, when final, will more than double the number of pollutants subject to federally enforceable standards. The proposals also call for monitoring 110 currently unregulated contaminants. EPA also laid out rules for how industrial facilities, cities, and counties can obtain permits for discharging stormwater into municipal sewage systems.

  EPA, USDA, DOD, and DOI are working with the Water Pollution Control Federation, a private group, on cooperative projects to improve the nation's water quality. EPA reinvigorated a task force charged with developing a national groundwater protection strategy and initiated a dialogue with a range of interested parties.

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In 1990, Congress increased funding for a coordinated, interagency Water Quality Initiative.

- **Wetlands.** To address the need to reduce wetland losses and also register wetland gains, the Administration and Congress have devoted considerable budget resources to wetland programs. The fiscal 1991 appropriations for existing wetlands programs, including the national wetlands inventory and the bay and estuary program, included a 17-percent boost over fiscal 1990, following a 38-percent increase in 1990 over 1989 levels. The Administration's fiscal 1992 budget request for all wetland activities totals $709 million, a 48-percent increase over the enacted 1991 level.

  In 1990 Congress passed legislation[26] authorizing the federal government to spend up to $26 million a year to purchase wetlands to implement a 1986 U.S.-Canadian agreement, the North American Waterfowl Management Plan. Pursuant to the plan, the DOI/Bureau of Reclamation and Fish and Wildlife Service signed agreements to cooperate on an inventory and expansion of wetlands breeding habitat for numerous species.

Among various wetlands acquisitions and other projects, the Department of the Interior added 106,000 acres to the Everglades National Park pursuant to the Everglades National Park Protection and Expansion Act.[27] DOI also developed a mitigation and enhancement plan for Kesterson Reservoir in California, almost tripling wetlands acreage in that area.

BLM began its Riparian-Wetland Initiative for the 1990s, which will restore and maintain the 23.7 million acres of these habitats on BLM lands toward a goal of having 75 percent or more in proper functioning condition by 1997. The project includes tree planting and revegetation, improved management and protection techniques, a public education and training program, and increased partnerships with state and local governments and private organizations. One of the most notable efforts has involved the cooperation of Trout Unlimited and the Izaak Walton League in the improvement of degraded riparian habitats in California, Oregon, and Nevada through tree planting, stream bank stabilization, and fencing.

During the summer of 1990 the President's Domestic Policy Council Task Force on Wetlands held public meetings in six regions of the country to obtain public comment on appropriate strategies for working toward the President's goal of "no-net-loss of wetlands." Also during the summer, the four agencies that use the Federal Manual for Identifying and Delineating Wetlands held public hearings to obtain technical comments for revising the manual. EPA and the Army Corps of Engineers, which together administer Section 404 of the Clean Water Act related to wetlands, signed an agreement in February 1990 to clarify aspects of wetlands policy.

Enhanced criminal enforcement and highly publicized tough sentences for those who illegally fill wetlands is proving to be an effective deterrent to wetlands loss.

Wildlife

- **Desert Tortoise.** The DOI/Fish and Wildlife Service (FWS) issued an emergency listing of the desert tortoise as an endangered species in southern California, Utah, and Nevada. A Desert Tortoise Rangewide Plan is drawing together federal and state agencies, the livestock industry, and wildlife organizations in a coordinated effort.

- **Enforcement.** In 1990 DOJ convicted almost 250 violators for illegal activity under the wildlife laws.

- **Fish and Wildlife 2000.** The DOI/Bureau of Land Management (BLM) began implementing a plan called "Fish and Wildlife 2000" by taking actions to improve fisheries and anadromous fish habitats. BLM initiated several joint waterfowl habitat improvement projects with private groups and continued efforts to improve and expand habitat for desert bighorn sheep and raptors. Some three dozen organizations contributed more than $2 million in funds, labor, and materials to help implement the overall plan.

- **Fisheries.** The President supported continuation of the Wallop-Breaux Trust Fund used for fisheries protection and development. BLM joined with a private group, Trout Unlimited, in a cooperative effort to maintain and improve trout fisheries at Bureau of Reclamation projects. BLM completed an assessment of needs for the next five years in riparian management and improvement, and BLM and the Forest Service adopted a National Recreational Fisheries Policy to promote and enhance fishing opportunities on the lands they manage.

- **Florida Panther.** DOI acquired 25,000 acres of habitat in south Florida for the Florida panther, one of the nation's endangered mammals.

- **Partnerships.** BLM signed national agreements with the Rocky Mountain Elk Foundation, Quail Unlimited, the National Wild Turkey Federation, B.A.S.S., Defenders of Wildlife, the Foundation for North American Wild Sheep, Trout Unlimited, and the Mule Deer Foundation. BLM, FWS, the National Park Service in the Department of the Interior and the USDA Forest Service continued to develop new and existing partnerships.

- **Spotted Owl.** After an extensive public comment period, the FWS listed the northern spotted owl as a threatened species throughout its range in Washington, Oregon, California, and British Columbia. In response, DOI and USDA announced a package of measures to set aside a significant amount of old-growth forest as protected owl habitat and to revise federal agency practices to balance jobs protection in the Pacific Northwest with preservation of the owl.

- **"Watchable Wildlife."** This BLM program, implemented in partnership with other federal and state agencies and conservation organizations, promotes opportunities to study, photograph, or simply observe the variety of species on BLM lands. In 1990 a public informational brochure on the program was published in cooperation with the Defenders of Wildlife organization.

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10. Wallkill River National Wildlife Refuge Act; National Fish and Wildlife Foundation Establishment Act Amendments of 1990; New England Fishery Resources Restoration Act of 1990; Pollution Prosecution Act of 1990; National Forest Foundation Act, 16 USC 1447a *et seq.* (West Supp. 1990).
11. U.S. Environmental Protection Agency, Science Advisory Board, Relative Risk Reduction Strategies Committee, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection* (Washington, DC: EPA, 1990).
12. National Defense Authorization Act for Fiscal 1991; Strategic Environmental Research Program Act of 1990, 50 USC 1521 (West Supp. 1990).
13. National Environmental Education Act, 20 USC 5501-5510 (West Supp. 1990).
14. U.S. Environmental Protection Agency, *The Nation's Hazardous Waste Management Program at a Crossroads: The RCRA Implementation Study* (Washington, DC: EPA, 1990).
15. Antarctica Protection Act of 1990, 16 USC 2461-2466 (West Supp. 1990).
16. International Development and Finance Act of 1989, 22 USC 2051 (West Supp. 1989).
17. Global Change Research Act of 1990, 15 USC 2921 *et seq.* (West Supp. 1990).
18. The Forest Service Program for Forest and Rangeland Resources; a Long-term Strategic Plan (May 1990 amendments to Forest and Rangeland Renewable Resources Planning Act of 1974 as amended; 16 USC 1600-1614 *et. seq.*) (West Supp. 1990).
19. Tongass Timber Reform Act, 16 USC 539 (West Supp. 1990).
20. Arizona Desert Wilderness Act of 1990, 16 USC 460 (West Supp. 1990).

21. Nevada Wilderness Protection Act of 1989, 16 USC 1132 (West Supp. 1990).
22. Aviation Safety and Capacity Expansion Act of 1990, 49 USC App. 2201 nt (West Supp. 1991).
23. Coastal Barrier Improvement Act of 1990, 42 USC 9831 *et seq.* (West Supp. 1990).
24. Great Lakes Critical Programs Act of 1990, P.L. 101-596, 104 Stat. 300.
25. Oil Pollution Act of 1990, 33 USC 2701 (West Supp. 1990).
26. North American Wetlands Conservation Act, P.L. 101-233.
27. The Everglades National Park Protection and Expansion Act of 1989, P.L. 101-229.

The Nature Conservancy

Poets are not immune to economic choices, as the words of Robinson Jeffers attest:

> ***I have still a furlong of granite cliff,***
> ***on which the Pacific***
> ***Leans his wild weight . . .***
> ***. . . One has to pay for it;***
> ***The county taxes take all my income, and it***
> ***seems ridiculous***
> ***To hold three acres of shorelong woodland***
> ***And the little low house that my own hands***
> ***made, at the annual cost***
> ***Of a shiny new car. Never mind, the trees***
> ***and the stones are worth it.***[1]

CHAPTER 2

MAKING THE ENVIRONMENT COUNT

Great voices of environmental concern such as John Wesley Powell, Theodore Roosevelt, John Muir, and Gifford Pinchot went beyond the economics of their day to establish their sweeping environmental and conservation visions, but they were also familiar with the economics of everyday activities. Consider the words of John Muir during his thousand-mile walk to the Gulf of Mexico:

> *Gold is found in small quantities throughout the Alleghanies, and many farmers work at mining a few weeks or months every year when their time is not more valuable for other pursuits. In this neighborhood miners are earning from half a dollar to two dollars a day . . . Common labor is worth ten dollars a month.*[2]

Indeed, naturalists, poets, business people, and shoppers know the value of a dollar well spent. Prices and costs affect people's choices of everything from how to produce a product to which trash bag to purchase. These choices affect the environment directly and indirectly in many ways, but the information traditionally used to make and describe such choices has seldom captured environmental impacts. In the 1990s new ways of accounting for the value of the environment are helping to generate better decisions that integrate economic and environmental interests.

Environmental economists study the economic conditions for the integration of economics and the environment. Such integration is achieved by the optimal balancing of costs and benefits and by selecting the least-cost method of attaining a target level of environmental quality.[3] Economists also develop market-based approaches to achieve this integration. The use of these market-based mechanisms to achieve economic and environmental goals is expanding, as discussed in this chapter. In contrast, most existing environmental policy employs direct regulation. Such regulations often bear little relation to economic principles, but they can alter the decisions made by businesses, consumers, and workers in both positive and negative ways. Accounting practices translate the costs and benefits of existing regulations into information for business decisions. New ways of accounting, based on better information and principles of environmental economics, are leading to new decisions that achieve environmental objectives in a more efficient way. An additional result of accounting for the environment may be more efficient production of goods and services that will help make American products more competitive on the world market.

Although many people perceive accounting to be humdrum, mundane, and boring, it is fundamental to management and consumer decisions. Accounting affects prices and even the decision of how to produce or whether to produce something for the economy. If the accounting system is faulty, production and consumption decisions will likewise be faulty. Until recently, accountants did not generally examine the environmental effects of production and consumption decisions. Nothing in the financial statement distinguished between a firm that worked hard to preserve environmental quality and one that devoted little effort to pollution control.

Without such detailed accounting, environmental effects tend to be ignored, even by socially conscious firms. Environmental accounting can help answer for individual consumers, retailers, or manufacturers such basic questions as: Should I use paper or plastic shopping bags? Recycle or landfill soft drink containers? Use chemical *x* or chemical *y* in a production process? Generate electricity with low-sulfur coal, install a scrubber, or change fuels? But changes in government and corporate policy as well as in consumer preferences are spurring changes in accounting for the environment.

This chapter reviews the many ways that environmental effects already count in economic activity, and it points toward additional ways in which a better accounting could be attained. The discussion explores the ways in which environmental protection is associated with costs and with benefits. Examples involving the actions of firms and consumers—the microeconomic level—are followed by a discussion of the actions of industries and the national economy—the macroeconomic level.

Making the Environment Count: Costs

Environmental problems are clear evidence of how markets can sometimes fail to achieve the wellbeing of a society. In unrestricted markets, environmental problems arise when individuals and businesses fail to take fully into account the environmental consequences of their decisions. The omitted elements are called *externalities*. The prescription offered by economists is to make buyers and sellers take into account all the effects of their actions and so "internalize" the externality. When such accounting occurs, the reoriented market recaptures its ability to achieve the wellbeing of society.

In environmental policy debates, there is a large and growing interest in the use of market-based policies that provide direct economic signals for taking the external effects into account.[4] Market-based policies discussed in this chapter include taxes on chlorofluorocarbons (CFCs) and the potential for buying and selling emissions allowances as provided for in the Clean Air Act Amendments of 1990.

Most existing environmental regulations do not provide direct economic signals regarding environmental externalities, but they do provide certain incentives. As stated by Robert Bringer, Vice President of Environmental Engineering and Pollution Control for The 3M Company, "We are trying to develop new products more quickly, but regulations have the opposite effect; they are time expanding. So if we get rid of the pollution, we get out from under the regulations."[5]

Most government regulations to protect the environment—such as those affecting hazardous waste disposal, discharges into waterways, or automobile emissions—succeed in reducing pollution but often impose high costs on society by requiring expensive control technologies or production processes. In other areas, such as oil production from the Outer Continental Shelf or use of parklands, the government collects fees to fund programs that manage or preserve environmental amenities or provide environmental cleanups. Some of these government-imposed costs cannot be avoided if the company is to stay in business or if a consumer decides to buy the product or use the service. Truly fixed costs of this sort provide little or no incentive to alter behavior. Other, more flexible government regulations provide incentives for businesses or individuals to change their behavior. Careful attention to the processes that produce pollution is providing evidence that many costs can be avoided or reduced, especially in the longer term, if a company substitutes alternative materials or energy sources, recycles materials, or redesigns the product, or if consumers make different purchasing decisions.

S.C. Delaney, EPA

Both a firm's existing and potential environmental liabilities have become items of concern for accountants.

The Cost of a Clean Environment

Recently, the Environmental Protection Agency (EPA) released new information on the past and predicted costs of providing a clean environment.[6] The report summarized data on investment and operating costs in several different categories for pollution control from 1972 to the present and projected costs through the year 2000. One category addressed the source of expenditures—whether pollution controls were paid for by federal, state, local, or private funds. Another category broke down the costs according to the various environmental media and several pollution sources: air and radiation, land, water, chemicals, and multimedia. A third category compared the actual costs incurred with the estimated costs necessary to achieve "full compliance" with the national ambient air quality standard (NAAQS) for ozone and the goal of "fishable and swimmable" waters.

Annualized costs, composed of operating costs and the interest and depreciation associated with cumulative pollution control investments (using a 7-percent rate of interest), are presented in Table 2-1 and in Figure 2-1. Total annualized costs were estimated to be $115 billion in 1990 (in 1990 dollars), or 2.1 percent of the U.S. real gross national product (GNP). Pollution control costs as a share of GNP have more

Table 2-1.—Total annualized costs of U.S. pollution control for 1972 and 1987 and projections for 1990 and 2000 at present and full implementation.

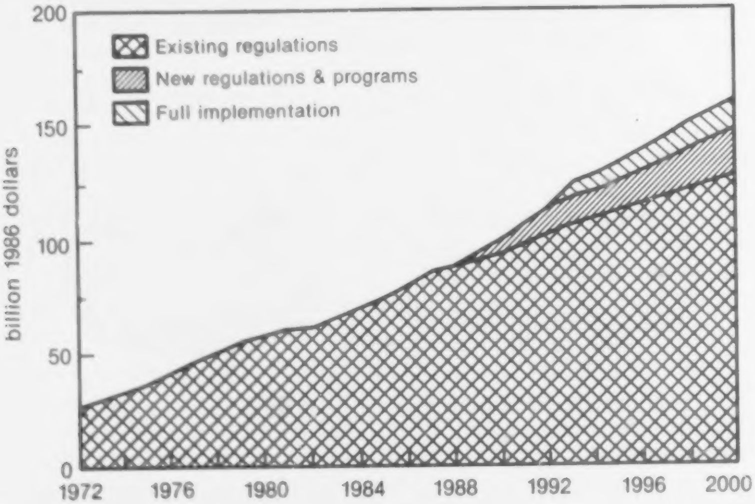
	TOTAL ANNUALIZED COSTS		
YEAR	1986 DOLLARS	ESTIMATED 1990 DOLLARS	GNP
	billion $	*billion $*	%
1972	26	30	0.9
1987	85	98	1.9
1990	100	115	2.1
2000			
Present	148	171	2.6
Full	160	185	2.8

Note: GNP = U.S. Gross National Product
Source: U.S. Environmental Protection Agency, *Environmental Investments: The Cost of a Clean Environment*, EPA-230-11-90-083, (Washington, DC: EPA, November 1990).

than doubled since 1972 and may be almost triple the 1972 figure by the year 2000. U.S. real GNP growth was also large during the 1972-1990 time period, so that the absolute level of pollution control costs increased roughly fourfold during those years.

New regulations, such as those for the land disposal of hazardous waste and for underground storage tanks, together with increases in existing regulations, are projected to increase pollution control costs to 2.6 percent of real GNP in the year 2000. The Clean Air Act Amendments of 1990 will require costs that represent a portion of the cost of reaching the full attainment level. The trends for costs of existing and new regulations, and the estimated amount necessary to achieve full implementation are presented in Figure 2-1.

Figure 2-1.—Total annualized costs of U.S. pollution control by type of regulation, 1972-2000.

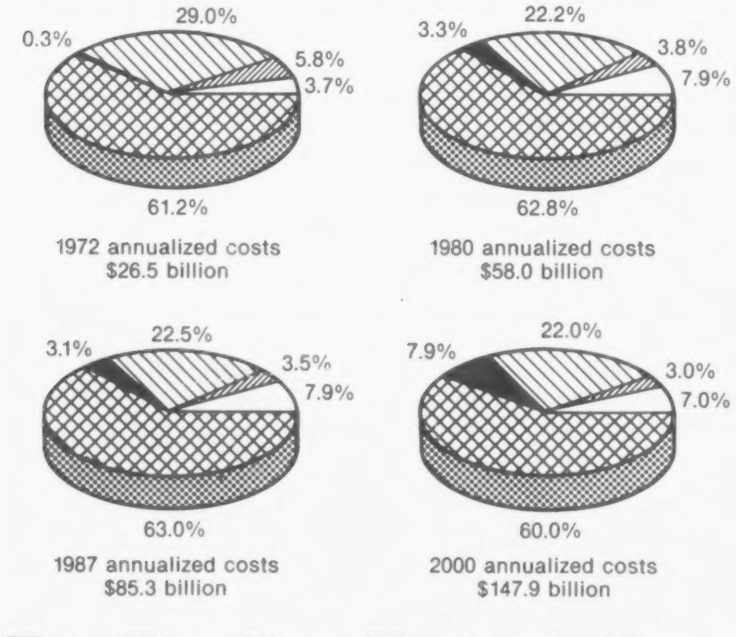


Source: EPA, *Environmental Investments*, page 2-1.

Private costs, which represent the majority of total pollution control costs, fall in the range of 60 to 63 percent over the period 1972-2000, as indicated in Figure 2-2. Non-EPA federal costs, primarily those associated with the industrial facilities of the Departments of Defense and Energy, are expected to grow rapidly in the 1990s. The total federal share may reach almost 15 percent of the total pollution control costs in the year 2000. The share of local costs is expected to remain constant, although in absolute dollar terms, pollution control costs by local governments are projected to increase by almost 50 percent in the next ten years.

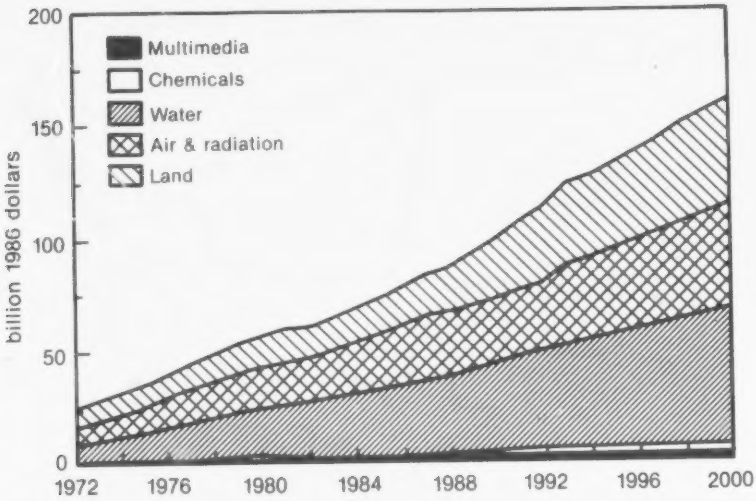
Despite the holistic character of the natural environment, U.S. environmental statutes and regulations usually have been specific to a single medium such as air or water. Costs to control pollution for the major mediums are presented in Figure 2-3. The largest share of control costs have consistently been associated with water pollution. However, in the next ten years a shift is expected toward an increasing relative share for control of land pollution. The share of costs associated with multimedia pollution control is currently projected to remain small at the turn of the century, roughly 1.5 percent of the total.

Figure 2-2.—Total annualized costs of U.S. pollution control by funding source for 1972, 1980, 1987 and projections for 2000, with present implementation in 1986 dollars.



Source: EPA, *Environmental Investments,* page 2-5.

Figure 2-3.—Total annualized media costs of U.S. pollution control assuming full implementation, 1972-2000.

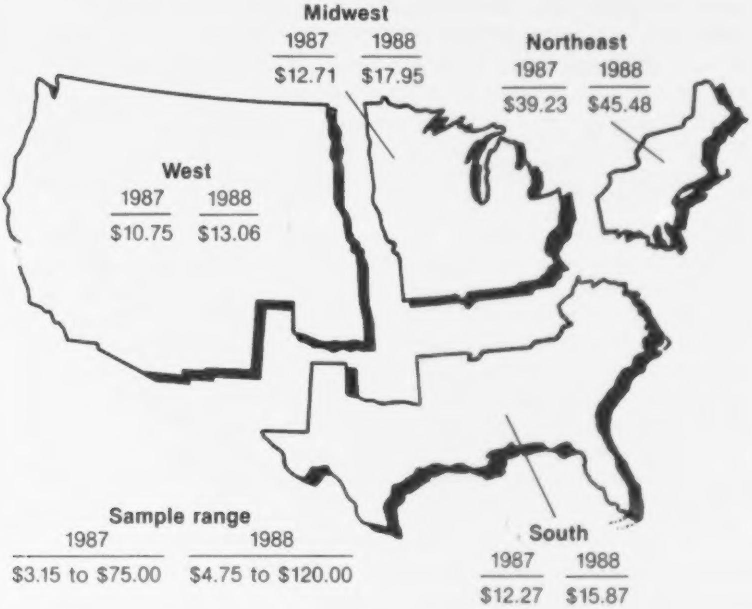


Note: Multi-media and chemicals near horizontal axis.
Source: EPA, *Environmental Investments*, page 3-1.

The trend of rising total pollution control costs represents both an increase in economic activity and in the unit costs of pollution control and disposal. That is, as economic activity increases, total operating costs for existing pollution control equipment are likely to increase, and new equipment may be necessary to meet expanded production. At the same time, new regulations are likely to increase the cost of producing each item. For example, implementation of regulations for solid and hazardous waste disposal is an element in the rapid increase of those costs. Figure 2-4 presents the increase in average costs of landfilling a ton of solid waste—the "tipping fee"—from 1987 to 1988. Average costs in the Northeast were three times the average cost in the West. Disposal of special categories of wastes, such as hazardous waste, were many times higher. Such increases in costs are an example of regulations that create incentives for firms that landfill waste to reduce the quantity of waste generated.

Government policies that raise the indirect costs of waste also create incentives for more careful accounting of industrial pollution outputs. A leading example is the public reporting requirement of the 1986 Superfund Amendments and Reauthorization Act.[7] Public disclosure of the amount of toxic materials released by some firms has created pressure on companies to reduce toxic releases. In accounting terms, the

Figure 2-4.—Regional tipping fee* averages for U.S. landfills, 1987-1988.



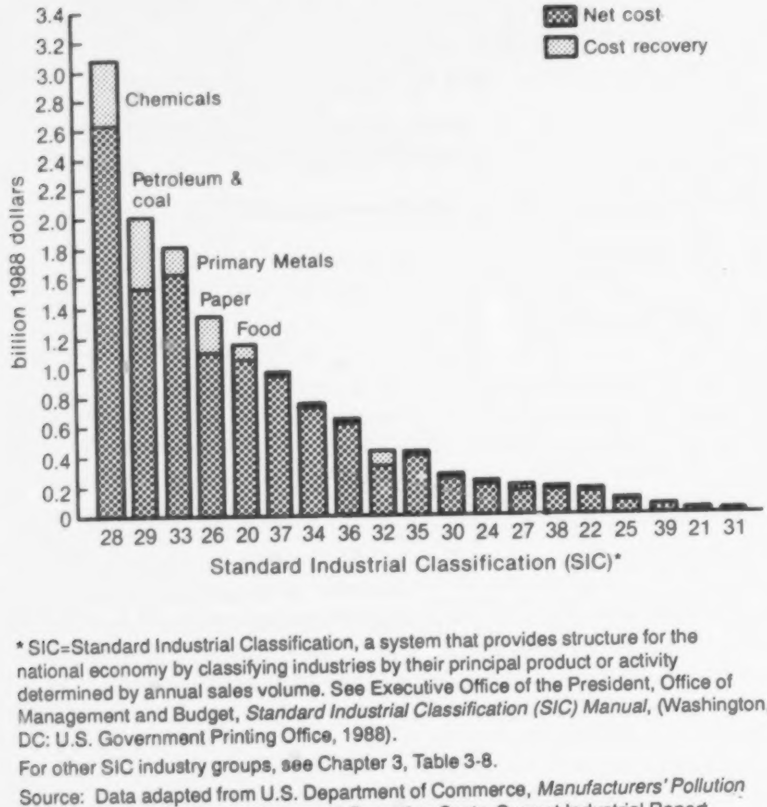
*Tipping fee = average cost of landfilling a ton of solid waste.
Source: National Solid Waste Association, "Tip fees up more than 30%," *Waste Age* 20(3):105, (March 1989).

firm loses goodwill by adverse publicity and may be subject to increased liability claims stemming from public knowledge of the release of toxic substances.

The concept of pollution prevention has become more prominent in industrial and governmental programs to improve environmental quality.[8] Techniques to prevent pollution include changing production processes to reduce the source of pollution, recycling components of the waste stream, or creating new products from a waste stream (see Chapter 3). Such activities can lead to the recovery of some or all of the costs invested in specific pollution abatement and control projects.

Most data on annual pollution control operating costs only report the gross cost of control before the recovery of some costs. However, a significant fraction of gross costs—15 percent in the chemical industry—is already self-reported by industry as being recovered through reduced costs or increased revenues. Figure 2-5 presents data for 1988 on the gross pollution abatement and control costs for selected industries and the share of those costs reported as recovered. Figure 2-6 presents data for the chemical industry for both gross and net pollution control

Figure 2-5.—U.S. pollution abatement and control costs and cost recovery by industrial code, 1988.



* SIC=Standard Industrial Classification, a system that provides structure for the national economy by classifying industries by their principal product or activity determined by annual sales volume. See Executive Office of the President, Office of Management and Budget, *Standard Industrial Classification (SIC) Manual*, (Washington, DC: U.S. Government Printing Office, 1988).

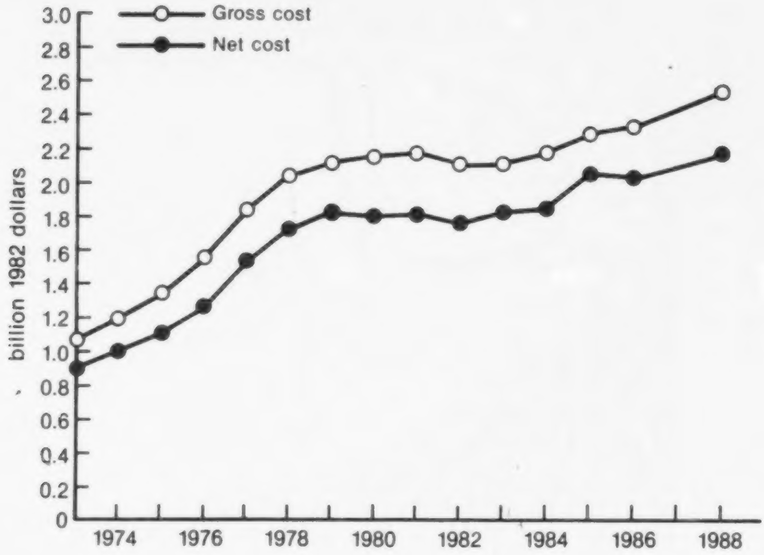
For other SIC industry groups, see Chapter 3, Table 3-8.

Source: Data adapted from U.S. Department of Commerce, *Manufacturers' Pollution Abatement, Capital Expenditures and Operating Costs*, Current Industrial Report MA200(88)-1, (Washington, DC: DOC, September 1990).

costs from 1973 to 1988. The rapid increase in pollution control costs has slowed from the period of the 1970s while the costs recovered have increased.

In summary, the United States is investing heavily in pollution control in an effort to improve environmental quality. Pollution control costs are approximately one-half of national expenditures on clothing and shoes and one-third of expenditures on national defense. The sections that follow illustrate how industry, regulated utilities, and the government are assessing these expenditures in new ways. Market-driven entrepreneurial efforts to reduce the costs of pollution control while improving environmental quality are leading to new ways of incorporating the environment into economic decisions.

Figure 2-6.—Real pollution abatement and control costs of the U.S. chemical industry in 1982 dollars, 1973-1988.



Source: Data adapted from DOC, *Manufacturers' Pollution Abatement.*

Industry

Environmental costs are an emerging issue in accounting standards throughout industry. The independent Financial Accounting Standards Board determines Generally Accepted Accounting Principles (GAAP) that guide accounting practices nationwide. For example, a key guideline is that reasonably certain and reasonably quantifiable liabilities should be reported in financial statements. In the past, the vagueness of this requirement left substantial discretion to individual companies. However, to comply with these standards and to assist businesses in making cost-effective, environmentally conscious decisions, accountants are devoting increasing attention to existing and potential environmental liabilities.

The trend has been reinforced by government oversight. In 1990 EPA began to report routinely on industrial environmental liabilities to the U.S. Securities and Exchange Commission (SEC), which protects the interests of the public and investors through disclosure of corporate financial information and enforcement of securities laws. The information reported by EPA includes:

- Information on pending liability cases under the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA);
- Information on all recently concluded civil and criminal cases under federal environmental laws;
- A list of facilities subject to cleanup under RCRA; and
- A list of facilities barred from government work under the Clean Water Act and the Clean Air Act.[9]

This shared information provides a valuable source of "reasonably certain" environmental liabilities.

While government policies to disclose liability information can directly influence the reporting of costs , many businesses are paying increased attention to potential liability exposure in their own self-interest. The practice of environmental auditing—systematically analyzing compliance with environmental regulations—has grown more commonplace since its development in the late 1970s.[10] Environmental auditing provides information that helps integrate regulatory costs and liabilities into an accounting framework.

Accountants themselves are also questioning which environmental liabilities should be accounted for in their analyses. For example, owners of hazardous waste injection wells and wells that reinject wastes from oil and natural gas production must demonstrate a financial capability to plug the wells with cement when they are abandoned. Some accountants are going further, asking to what extent an accountant should consider costs other than simply plugging and abandoning waste injection wells and whether new methods exist to predict the financial capability of a firm to meet its environmental responsibilities.[11]

Currently, when environmental liabilities enter the accounting statements of firms, their net worth falls. This recognition of environmental liabilities is a relatively new development, one reason why many companies unwittingly contributed to environmental pollution in the past. Today, a lower net worth undercuts a firm's ability to attract investors—providing a strong incentive to avoid such liabilities. Bankruptcy filings have been based on environmental liabilities, such as asbestos claims, and economists are studying environmental accidents and landfill closures related to environmental issues for their effects on stock market prices.[12]

Although most firms do not account fully for all the quantities and costs of wastes, the evolution of good business practice is leading to better accounting for the environmental impacts of business decisions. For example, a new effort called the Global Environmental Management Initiative, launched in 1990 by a coalition of major U.S corporations, aims to achieve international environmental goals by continuously improving and disseminating advanced environmental management practices. The federal government's contribution is to provide information and leadership on the best environmental management practices in private industry. For example, President Bush established the Presidential Commission on Environmental Quality, to be composed of leaders from the private sector, nonprofit environmental and conservation groups, and academia. Commission members will be selected for their capacity to lead society by the example of their own organizations and also for their ability to be catalysts toward wider private initiative on the cutting edge of environmental practice.

In support of demands for more and better data on the environment, many federal programs that compile environmental and economic data are expanding research, collection, and publication of such data. While these government programs stimulate private sector reporting and provide aggregate information, the frontier of accounting for the environment is being explored in millions of companies throughout the American economy. Case studies for the Polaroid Corporation and E.I. duPont de Nemours and Company (hereafter referred to as DuPont) demonstrate two ways that the environment can be incorporated into corporate accounting.

A crucial number to any corporate executive or economic analyst is productivity—a measurement of output per unit of input. Just as managers may measure the efficiency of labor, equipment, and materials by assessing the resulting productivity, similar ratios may be calculated for the relationship between output and wastes. Incentives for product managers to reduce pollution become more direct when such efficiency measures or their costs are associated with processes under their control. Improvements in information management clarify the existing incentives to reduce pollution when all technical efficiencies are monitored and the costs of waste are perceived as avoidable.

Some firms are also accounting for the environment by allocating to particular products the dollars spent on pollution abatement and control. In the late 1970s individual plant managers in chemical and other industries began to build tracking and accounting systems to allocate off-site and on-site waste disposal costs to particular products. These accounting efforts helped identify actions that could be taken to reduce costs or increase revenues, such as:

- Increased recycling of catalysts,
- Development of new products,
- Construction of EPA-approved co-generating plants, and
- Increased waste and water separation.

S.C. Delaney, EPA

As the cost of waste disposal rises, financial incentives point in the direction of pollution prevention.

Studies of the diffusion of process and management changes have found that many technological and managerial details affect the successful diffusion of technological change.[16] The expansion of accounting for the environment and the changes associated with pollution prevention are also examples of the diffusion of new technologies.

The case studies of Polaroid and DuPont indicate that careful, integrated attention to environmental and economic information can directly alter business decisions—to the benefit of stockholders, consumers, and the environment.

CASE STUDY

EARS: The Polaroid Corporation

Polaroid has developed an innovative chemical accounting system, the Environmental Accounting and Reporting System (EARS). It tracks quantities of chemicals used in the production of outputs such as cameras and film. Polaroid's accounting system distributes wastes into four categories according to the degree of risk posed to the environment. Category I, representing the greatest risks, includes CFC-113, an ozone-depleting chemical used as a solvent for cleaning electronic circuit boards. Nationwide in 1988 industries reported the increase of 68.5 million pounds of CFC-113—primarily into the air; Polaroid's releases from its camera division were almost 60,000 pounds.[13]

In 1990 the United States began taxing CFC-113 and related chemicals as an incentive for phasing them out totally by the late 1990s, consistent with the 1990 London Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer. The tax on CFC-113 in early 1991 was over 25 percent of the wholesale price. By accounting carefully for the costs and quantities of CFC emissions, Polaroid found ways to cut CFC pollution, avoid taxes, and cut production costs. The company installed a closed-loop recycling system that reduced air releases from the camera division to 2,000 pounds and resulted in a net savings of $75,000 per year from reduced disposal costs and purchases of CFC-113.[14] This is an example of how a market-based incentive approach combined with economic accounting can be successful. In short, a 97-percent reduction in this serious form of air pollution represented a major gain for the environment and made economic sense as well.

Table 2-2 presents EARS data for Polaroid's Category I chemicals.[15] The CFC-113 reduction is seen in Category I releases from the camera division. In the base year of 1988, 26.94 units of waste were reported for each unit of camera production. In 1989 that number fell to 7.76 units.

Table 2-2.—Units of pollution per unit of production reported in the Polaroid Corporation Environmental Accounting and Reporting System (EARS), 1989.

DIVISION	UNITS OF PRODUCTION	UNITS OF POLLUTION*/UNIT OF PRODUCTION	
		1988 TOTAL (BASE YEAR)	1989 TOTAL
Camera	cameras	26.94	7.76
Reagent Manufacturing	kg	6.70	3.90
Negative Manufacturing	sq. ft.	119.59	129.20
Integral Coating	sq. ft.	5.09	3.29
Industrial Coating	sq. ft.	1.05	1.23
Battery	batteries	1.28	.93

*Units of measure withheld to avoid disclosure.

Source: Adapted from Polaroid Corporation, "A Report on the Environment," (Cambridge, MA: Polaroid Corporation, 1989) and supplemental data.

CASE STUDY

Waste Tracking and Accounting: DuPont

An example of the diffusion of financial accounting for the environment is DuPont, which has supplemented its waste reduction and training efforts with a new manual designed to standardize waste tracking and accounting at the plant level. As the firm with the largest number of facilities (74) reporting toxic releases under the national Toxics Release Inventory (TRI, see Chapter 3), DuPont's accounting systems are of special interest.

Figure 2-7 presents an example of DuPont's cost and waste management information for contract costs of waste management. The firm identified several opportunities for waste and cost reduction in this case, but the brackets in the figure illustrate one of the most dramatic: a process change within the chemical plant that reduced the quantity of waste generated by 84 percent. This in turn reduced the number of loads removed from the site from seven in the first five months of 1984 to only one load in the second half of that year. Considering the aggregate result of many projects of this kind, DuPont estimated that its waste reduction program achieved savings of approximately $50 million in management and disposal costs in 1990.

Figure 2-7.—A cost-tracking chart from the DuPont Company's Cost Accounting System for Waste Reduction, 1990.

Description	Ticket Number	Quantity*	Ship Date	Carrier	Trans. Charge	Disposal Charge	Service Charge
Bldg. 534 waste water	1756	38,000	01/10/84	bonded	372.00	1,588.00	150.00
Bldg. 534 waste water	2105	39,900	02/05/84	bonded	372.00	1,490.00	175.00
Bldg. 534 waste water	2450	38,500	02/28/84	bonded	372.00	1,710.00	150.00
Bldg. 534 waste water	2920	40,000	03/15/84	bonded	372.00	3,200.00	150.00
Bldg. 534 waste water	3208	39,500	03/29/84	bonded	372.00	1,480.00	600.00
Bldg. 534 waste water	3410	20,000	04/18/84	bonded	372.00	810.00	150.00
Bldg. 534 waste water	3540	36,000	05/30/84	bonded	372.00	1,350.00	150.00
Bldg. 534 waste water	7518	39,500	11/15/84	bonded	372.00	1,650.00	150.00

*Units of measure withheld to avoid disclosure.

Note: A new pollution prevention process accounted for the gap in waste water shipments between 5/30/84 and 11/15/84.

Source: E.I. du Pont de Nemours and Company, personal communication, 1990.

Electric Utilities

Changes in regulatory and company practices are also making the environment felt on the bottom line of the electric utility industry. Electric utilities, which provide approximately one-third of the total energy used in the United States, are highly regulated. Most direct regulation occurs at the state level.

Along with less-regulated companies, electric utilities are beginning to expand their financial accounting to reflect the costs of environmental regulations and investments in end-use energy efficiency. Innovative programs in several states, including New York and New Hampshire, have led to environmental cost add-ons for technologies with different environmental effects. The electricity supply decision then is based on both the usual costs incurred by utilities and the estimated additional environmental costs.

Changes in regulations are also emerging that affect the way that utilities can earn income. Traditionally, utilities have earned income only by selling power at regulated prices to anyone connected to the utility grid. Increased demand was met by building new generating capacity. But today, as electrical generating capacity becomes more expensive to construct, utilities are supplementing new capacity decisions with efforts to make electric consumers more energy efficient. Regulatory and accounting methods are evolving to enable utilities to earn a return on efficiency investments commensurate with that earned on supply-side investments. Fuel use and pollutant emissions are lowered with no reduction in the quantity of energy services supplied.

While many investments in energy-efficient technologies—such as variable speed motors and high efficiency lighting and cooling systems—will be undertaken by consumers and industry, electric utilities are well placed to speed the diffusion of energy efficiency improvements in the economy. Some estimated rates of return on these type of improvements exceed 20 percent,[17] and preliminary estimates of net savings to consumers from removing regulatory disincentives to such investments approach $1 billion per year.[18] A more extensive discussion of these programs appears in Chapter 3.

Further innovations in accounting for the costs and revenues of the utility industry are being prompted by the implementation of the Clean Air Act Amendments of 1990. The amendments employ marketable emission allowances as part of a program to cap sulfur dioxide emissions from electric utilities at 8.9 million tons per year, roughly 50 percent below the 1980 level. In simplified terms, the federal government will issue emission allowances to utilities whose powerplants emit sulfur dioxide, and emissions in excess of allowances will be prohibited. Utilities may buy and sell these allowances, which are likely to be worth several hundred dollars each, though the actual price will be determined by supply and demand.

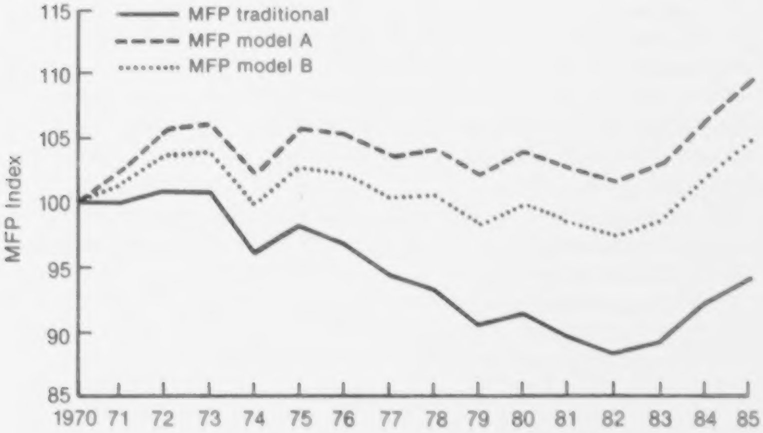
Emission allowances will represent an added cost as well as a potential source of revenue. Those utilities that can reduce emissions for an added cost that is less than the market price of the allowance will have a direct financial incentive to reduce emissions and sell the unused allowances for a profit. Some utilities are reportedly considering this strategy of over-compliance to improve their financial position.[19] In accounting terms, allowances have the potential to become marketable assets of the utility where each allowance will be either used as a necessary resource for producing electricity or sold to generate additional revenue.

In aggregate, the use of these marketable allowances is estimated to save 20 percent annually or roughly $1 billion per year compared with the cost of achieving the same level of pollution control through government-mandated technologies.[20] The market-based approach provides both market prices for valuing emission reductions by companies and the flexibility to achieve environmental goals at the least cost. The Clean Air Act Amendments also require EPA and the National Acid Precipitation Assessment Program (NAPAP) to commence economic analyses of the costs and benefits of the statute. Such analyses are necessary to weigh the relative merits of environmental policies based on technology mandates versus market-based approaches.[21]

As in the case of less-regulated industries, productivity for electric utilities can be measured in various ways. A policy concern since the 1970s has been the falling productivity of electric utilities, commonly measured by ratios of output to inputs, for example, kilowatt-hours-per-person-hour or by more complex measures called *multifactor productivity indices* (MFP). MFP indices are the economically preferred measure when there are multiple outputs and inputs. Environmental regulation is a commonly cited cause of the decline in electrical productivity.[22] Pollution control technologies required by environmental regulations cause electric utilities to produce significantly less pollution but also less electrical output for each unit of input. However, accounting comprehensively for the multiple outputs of electricity production—emissions as well as electricity itself—suggests that productivity has actually increased since the 1970s.[23]

When emissions are considered as an output along with electricity in the measurement of utility productivity, the emissions are assigned a negative price equivalent to the damages associated with their release. In economic terms, this is equivalent to assigning a cost to emissions in the construction of a multifactor productivity index.[24] The lowest line of Figure 2-8 indicates that the productivity of electricity output, with electricity as the only output, has declined relative to the 1970 level. However, with emissions included as another output, estimates of total productivity increase over the same time period, as shown by the top two lines. The top lines each represent different ways of adjusting the costs of emissions over time.

Figure 2-8.—Multifactor productivity (MFP) of electric utilities in the United States, 1970-1985.



Source: Repetto, R., "The Concept and Measurement of Environmental Productivity," Background paper for the *Toward 2000 Conference*, (Washington, DC: World Resources Institute, 1990).

These particular results are driven by the costs associated with emissions. Different estimates of these costs change the specific results but not the general conclusion: various ways of measuring productivity can lead to different perceptions of progress and different decisions in industry and in government.

Public-Private Partnerships

Government accounting is fundamentally different from that of the private sector because government agencies focus on annual appropriation cycles and often do not integrate the accounting of assets and liabilities. Nonetheless, as in the private sector, cost accounting is essential in all sectors of government—federal, state, and local. In some agencies, accounting for natural resource assets is receiving new attention.

Many of the same environmental regulations that affect industry also affect government services. In 1990 all levels of government spent $37 billion (in 1986 dollars) on pollution control costs.[25] Government costs are expected to grow to $59 billion (in 1986 dollars) by the year 2000. Environmental regulations affect hazardous and nonhazardous waste disposal, the cleanup of wastewater, the supply of clean water, and other public-sector tasks. A growing literature comparing government and private-sector efficiency suggests that private-sector practices can improve the efficiency and lower the cost of government operations.[26] Like industry, the public sector is pursuing innovative strategies to reduce costs of regulation or increase revenues associated with environmental effects.

One way that government agencies tap the technical expertise and financial power of the private sector is through public-private partnerships. Public-private partnerships may fall under the rubric of *privatization*, in which government agencies exploit the cost-consciousness of private-sector managers. Through the Public-Private Partnership (P3) initiative, for example, EPA encourages private-sector involvement in local efforts such as the treatment and disposal of solid waste, wastewater, or the management of drinking water.[27] Acting as a liaison among government, industry, and academia, EPA coordinates partnerships by providing how-to guidelines for state and local governments.

Another EPA partnership program is called "Green Lights." This new program encourages major U.S. corporations to install energy-efficient lighting technologies. Under this voluntary, nonregulatory program, corporate facilities will be upgraded with these technologies wherever they are profitable and maintain or improve lighting quality.

When the county of Charles City, Virginia, faced a landfill closing, privatization offered a solution to escalating environmental costs and budgetary constraints. In a public auction bid, the county hired Chambers Development Company to replace the public landfill with a state-of-the-art landfill operation. In the agreement, Chambers guaranteed the county of Charles City free refuse collection and disposal and also agreed to pay host fees that will yield approximately $1 million annually to finance a new school system.

Water treatment facilities present another area for changes in the practice of accounting, funding, and decisionmaking. For example, in Auburn, Alabama, city officials entered into a privatization partnership with Metcalf & Eddy, Inc., to design, build, operate, and own two wastewater treatment facilities. To finance the project, the city created an independent authority, the Government Utility Services Corporation, that issued tax-exempt bonds.

Some partnerships combine varying degrees of privatization with direct voluntary action. For example, local residents are among the most knowledgeable and committed advocates of protecting local natural resources such as wildlife habitats. In response to the initiative of private groups such as Trout Unlimited, B.A.S.S., Defenders of Wildlife, and The Nature Conservancy, the federal government is increasing the number of cooperative management and research projects carried out with citizen volunteers and personnel from the Department of Defense, the Forest Service in the Department of Agriculture, and the Bureau of Land Management and the Bureau of Reclamation in the Department of the Interior.

While the majority of programs to preserve and protect wildlands are operated by government agencies either alone or through partnerships, a growing number of such efforts are the result of independent private action. Private, nonprofit conservation groups such as The Nature Conservancy, the World Wildlife Fund, and the National Audubon Society have purchased millions of acres of endangered habitats in separate reserves or as adjunct parcels to protected federal lands. Nonprofit organizations also preserve sensitive lands as custodial trusts, in which grassroots groups or local governments band together to provide financing for the preservation of relatively small tracts of lands such as a park, wildlife refuge, or natural area. Today, over 750 public-private land trusts protect over 2 million acres.[28]

Private land management can also include multiple-use practices designed to generate income without damaging the environment. For example, on its 13,000-acre Pine Butte Reserve in northwestern Montana, The Nature Conservancy offers tours to view grizzly bears to support operating costs. Grazing allowances on select areas within the preserve net $10,000 annually.[29] On a 5,000-acre site of pasturelands and freshwater marsh near Port Arthur, Texas, Waste Management, Inc., has developed plans to protect and enhance these natural resources while also operating a hazardous waste disposal facility and one of the world's largest operating hazardous waste incinerators (see case study in Chapter 4.) In 1990 a group of private companies created the Corporate Habitat Certification Program, employing a noted wildlife biologist to inspect conservation projects on corporate property and certify whether they meet environmental criteria.

A middle ground exists between public and private ownership through the leasing of public land to the private sector.[30] Leasing is used for the development of a variety of natural resources ranging from grazing, to harvesting timber, to extracting coal, oil, or natural gas. In most instances, these leases are the result of an auction that grants extraction rights to the highest bidder. This process generates substantial benefits to U.S. citizens. Offshore oil and gas leases have generated nearly $100 billion in revenue to the federal government in the 40 years since they began, while timber, grazing, and coal leases have generated tens of billions of dollars in revenues.

However, controversy surrounds the leasing of natural resources because of concerns about environmental damage or the displacement of alternative uses of these areas. One perception is that the government does not properly account for the value of the environment in its leasing decision. The federal government does analyze potential environmental impacts in these leasing programs through the environmental impact statement process required by the National Environmental Policy Act and other procedures.[31] In its own self-interest, the private sector may also consider the potential liability for environmental damages in their bidding decisions.[32]

No auction has yet offered bidding rights for nondevelopment of resources. The auctions for resource leases allow bidding for only one outcome—exploration and possible development. A method for making the environment count in resource auctions might allow bidding for nondevelopment of the resources. By such a process, the value that people place on the environment might be revealed and accounted for in a way parallel to the value that people place on development.[33] While auctions would have to be crafted to account for the free-rider problem—people willing to pay but hoping that someone else will—and for differences in time periods for benefits from development compared with nondevelopment, the nation could harness the strengths of the marketplace to resolve some of the controversial stalemates in natural resource allocation.

The diversity of environmental and economic conditions across the country indicates the wisdom of increasing local accountability and management for many environmental quality programs. Nonprofit organizations and trusts that derive their strength primarily from their ability to attract and maintain donor-members are not immune from accounting issues. Profit-seeking firms often find that voluntary conservation projects improve employee morale and earn the firm valuable goodwill in the community. Partnership initiatives by both profit-seeking and nonprofit concerns offer a cost-reducing complement to public ownership in the national effort to enhance environmental quality (see also Chapter 4, "Linking Ecosystems and Biodiversity").

Macroeconomic Costs

Individual companies, governments, and institutions are taking creative steps to reduce their costs while providing the goods and services that represent the strength of the U.S. economy. As economic actors assess the details of their particular problems and opportunities, their individual actions aggregate to affect the larger economy.

Existing data on pollution abatement and control costs primarily illustrate the activities of individual firms and industries. Macroeconomic costs of environmental regulations may be substantially different when interactions of many markets are considered simultaneously. Macroeconomic costs may be smaller than the estimated costs to specific industries because of improved technology and the possibilities for substituting alternative products for those that become more expensive. Conversely, macroeconomic costs may be larger because of a ripple effect in corporate costs, the supply of labor, and the allocation of investment among projects. Macroeconomic models of the costs of environmental regulations, although still in the early stages of development, are relevant to both domestic environmental policy and to international environmental policy.

In general, macroeconomic effects—both costs and benefits—are less well understood than microeconomic costs and benefits. On the cost side, one key study published in 1990 indicated that gross macroeconomic costs (not including benefits) may exceed the microeconomic costs reported throughout this chapter.[34] Using 35 industry groups and estimates of substitution possibilities based on historical data, the study found that the effect of environmental regulations is to reduce the long-term real level of GNP by 2.5 percent. Estimates of the effect of regulations varied significantly by industry, depending on shifts of investment into pollution control. The study reported a positive effect of environmental regulations on international competitiveness. Another recent work concluded that macroeconomic costs may exceed microeconomic costs because workers decide to supply less labor in future years as environmental regulations reduce the relative productivity of labor.[35] In the second study, the higher macroeconomic costs also reflected measures of social wellbeing that included changes in what economists call total surplus—the difference between what consumers are willing to pay for goods and services and the price at which suppliers are willing to provide them.

Making the Environment Count: Benefits

The typical accounting statement provides the year's revenues, costs, and net income—the bottom line—in one package. A supporting statement provides the stock of assets and the liabilities. Having discussed the costs side of the ledger, this chapter now proceeds to the benefits side, which affects both the net income of companies and the measurement of assets.

Like the costs of environmental improvement, the benefits of such improvement vary widely according to specific circumstances. Benefits may also change along with consumer preferences. Among the benefits of environmental protection are the following:

- Reductions in human illness and premature death;
- Reductions in damage to living natural resources, materials, and other economic assets;
- Increases in outdoor recreational opportunities;
- Preservation of various aesthetic and spiritual benefits; and
- Continued opportunities to use the environment in the future.

The distinction between costs and benefits is specific to the way an issue is considered: if emissions rise, then additional damages may result that represent costs to society; but if emissions drop, then damages are avoided and represent benefits to society. In this case, the same monetary measurement can represent either costs or benefits. While this measurement issue is treated in context throughout this chapter, substantially less information is available on the benefits of environmental quality as opposed to the costs of implementing regulations. The evolution of making the environment count in social decisionmaking depends on expanding our knowledge of the benefits of environmental improvement, as well as costs.

Consumer Preferences

The strength of a market economy is its ability to respond to new incentives, especially the demands of consumers. This responsiveness is evident in the upsurge of products marketed as friendly to the environment—so-called "green" products. Competition and profit-seeking motives have led many firms to respond to changing consumer preferences by creating green products or marketing approaches.

A comprehensive study of consumer support for environmental products was made by the Roper Organization in July 1990.[36] The study found that about a quarter of all consumers considered environmental impacts at the point of purchase by taking such actions as reading labels, purchasing biodegradable garbage bags, buying low-phosphate soaps and detergents, and avoiding products in aerosol containers. About one in seven of those surveyed said they regularly buy products made from or packaged in recycled materials. Other studies confirm that consumer interest in green products has increased substantially.

Such consumer interest translates into increases in demand for green products. Business responds by altering its production, advertising, and labeling efforts to meet this demand. Indeed, a growing percentage of new products are touting some environmental benefit such as "ozone friendly," "recycled," or other claims.[37] Several events in 1990 reflected this trend, including decisions by several firms to market and label "dolphin safe" canned tuna (tuna caught by methods that avoided the accidental taking of dolphins) and efforts by major retailing chains to label and advertise the environmental qualities of certain products.

The rush toward green marketing has led to concerns in many quarters that claims such as "environmentally friendly" and "biodegradable" may be confusing or deceptive. Various efforts are underway to reduce the confusion and improve consumer information:

U.S. Department of Agriculture

One in seven consumers in a recent poll said they regularly buy recycled products.

- **Nonprofit Groups.** New organizations such as Green Seal and Scientific Certification's Green Cross are developing certification programs for products that claim environmental benefits.

- **States.** An *ad hoc* task force of state attorneys general held public hearings and brought together leaders of government, business, and environmental groups to assess ways to provide consumers with accurate information on the environmental impacts of their purchases.

- **Federal Government.** EPA invited the Federal Trade Commission and the U.S. Office of Consumer Affairs to form a joint task force and initiate a cooperative effort to promote national guidelines for the use of terms such as "recycled" and "biodegradable."

- **Private Sector.** A group of 24 companies and trade associations prepared a petition requesting the Federal Trade Commission to issue national guidelines on environmental advertising and marketing.

A persistent question involves consumers' willingness to back their professed desire to buy green products with actual behavior. The Roper study found wide variability among consumers in their commitment to the environment. Fully 48 percent of all consumers identified themselves as informed and sympathetic toward environmental products.

The average respondent was willing to pay 7 percent more for green products. Women, who continue to be the primary shoppers in most households, are far more likely than men to consider the environmental impacts of their purchases. But overall, the study identified a gap between American support for the principle of environmental marketing and personal efforts to be greener consumers.

The potential of environmentally safe products and services to help companies increase revenues will ultimately be determined as the marketplace sorts out winners and losers. But for many Americans, the environment already sells at the grocery store, at the hardware store, and at many shops in between.

Microeconomic Benefits

While it is relatively easy for a company to account for the direct benefits of increased sales of green products, the task is more difficult when benefits accrue outside of the marketplace, for example, in the health of individuals. Consumers cannot call a broker for a price quotation on ozone layer protection. In contrast, obtaining a price quote to buy a barrel of chlorofluorocarbons is relatively simple.

Many benefits of environmental improvement are not sold directly in a market, making a concrete valuation difficult. Moreover, most benefits typically result from *avoiding* damages to the environment. Recall the Sherlock Holmes story in which the crucial clue to solving a case was that a dog *did not* bark in the night.[38] Likewise, estimating the benefits of environmental improvement requires estimating the damages that *do not* occur as a result of altered behavior or technology. For instance, the environmental damages associated with producing electricity become the benefits when actions are taken to reduce emissions.

The concept of accounting for the benefits of environmental improvement has existed for years and has received renewed interest in recent years, although consistent and reliable estimates of such benefits are not yet available. EPA is expanding its efforts to monetize environmental benefits to complement its recent report on the costs of a clean environment. The Council on Environmental Quality and EPA also are implementing provisions of the Clean Air Act Amendments of 1990 that require scientific and economic assessments of the act's implementation, including benefits evaluation. In the international arena, the U.S. Global Change Research Program earmarks $17 million for economics research and almost $1.2 billion for Earth systems research—both of which should help improve estimates of the costs and benefits of various response strategies.

Research on the benefits of avoiding environmental harm is also being spurred by the 1986 Superfund Amendments and Reauthorization Act, the Clean Water Act, and by the Oil Pollution Act of 1990. These statutes make companies financially liable for direct damages not only to individuals but also to natural resources for which government agencies may act as trustees for all citizens. Since 1986 the U.S. Department of Justice has filed 11 cases involving natural resource damages, five of them in 1990 (other natural resource damage cases may never advance to the filing stage or may be years in preparation).

A pathbreaking example of such litigation involved pollution in the San Pedro Channel near Los Angeles, California. The case led to a $12-million partial settlement for the discharge of DDT and PCBs into the channel. In a case involving PCB contamination of New Bedford Harbor in Massachusetts, the parties reached a $66-million agreement in principle for cleanup, study preparation, and natural resource damages. These settlements are dwarfed by the $1-billion announced settlement for federal and state civil damages and criminal restitution resulting from the *Exxon Valdez* oil spill. The cost of studies on resource damages alone exceed $35 million for that case.

Natural resource damage litigation affects accounting for the environment in two ways. The first is to create a demand for methods to value the environment, especially those values lost as a result of oil spills or other kinds of contamination. The second effect is to increase the potential liabilities of firms that might cause environmental damage. As discussed earlier in this chapter, increased liability is a strong incentive for preventing pollution in the future.

Macroeconomic Benefits

Many studies illustrate various methods of estimating the benefits of specific actions to improve the environment. Until comprehensive estimates of benefits are more practicable, one approach is to aggregate isolated studies.[39] But in the transition from small-scale to large-scale actions, an economic principle is often overlooked.

This principle was first stated in the 1800s as the diamond and water paradox, but it has reappeared in the debate on how to value the free services of the natural environment. The paradox occurs because water, critical to life, was observed to have a small price relative to the price for diamonds, which are not essential to daily survival. The paradox is resolved by considering that the price of a good—its exchange value or marginal value—is the value of the last unit sold or consumed, not the total value of the good to the individual or society. In other words, while the total value of water is very high, the supply of water relative to its demand is sufficiently large that the value of the last unit of water is small. In contrast, while the total value to consumers of diamonds may be small, the supply is sufficiently limited relative to demand that the value of the last unit is rather high.

This principle of economics is often overlooked as people who believe the value of the natural environment is infinitely large are shocked by the meager values sometimes placed on individual parcels of trees, wetlands, or other natural resources. Consistent with the diamond and water paradox, while the total value of the services provided by the environment is in fact very large, the value of some of the smaller components may be small even if a proper accounting for unmarketed benefits occurs. However, as natural areas and systems are altered and used ever more intensively for human purposes, the value of the remaining portions of the natural environment can be expected to increase.

Most accounting reflects transactions at the prices that represent the exchange value of the last units bought and sold, not the total value. Even so, a different conception of economic activity and trends occurs when the many actions of individuals, companies, and governments are aggregated together. Economic leaders closely watch the national income accounts, including data on gross national product, net national product, and other measures that provide clues at the aggregate level of trends in economic activity. Improvements to these national income accounts in the future are likely to incorporate the role of the environment in generating national income.

A vision of comprehensive national environmental accounting far exceeds current measurement capabilities. Accounting for the value of natural resource commodities such as oil, natural gas, timber, and other land-type assets is somewhat easier, though difficulties remain.[40] Economists have developed preliminary estimates of the value of federal land holdings, including discovered and undiscovered oil and gas resources and urban land.[41] Production from these natural assets enters the measurement of GNP as timber, energy, recreation, and other goods and services sold in the economy.

However no reduction occurs in national income accounts when inventories of natural resources are drawn down. Several environmental economists have suggested adjusting the national income accounts for the production of current income through the extraction of natural resources.[42] These suggestions are preliminary, but they do indicate how changes in accounting measurement can change the perception of what constitutes economic wellbeing. When one nongovernmental, unofficial estimate of the cost of wetlands losses, farmland losses, and depletion of nonrenewable resources is subtracted from the reported value of the GNP, the level of GNP falls by over 5 percent.[43]

The formal development of supplemental national income accounts is being investigated by the United Nations with participation by the United States.[44] The Departments of Commerce, State, and Treasury and the U.S. Agency for International Development are also searching for ways to implement Congress' directive that the government should recognize "the depletion or degradation of natural resources as a component of economic activities."[45]

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Making the Environment Count: Goals and Tools

Accounting for the environment is still in its early stages at both the microeconomic and the macroeconomic level, but its function can be compared to the interaction of computer software and hardware. Computer hardware will perform poorly with inappropriate software just as business and government decisions can be inappropriate without the necessary data and tools.

The integration of economics and the environment has long been advocated by leaders and thinkers in many social roles. As President George Bush told delegates to the White House Conference on Scientific and Economic Research Related to Global Change in April 1990, what is needed is "an entirely new way of thinking" to achieve both economic growth and environmental protection, while sacrificing neither. But each policy issue requires its own balance between environmental and economic concerns. For some issues, such as the use of lead in gasoline, economic analysis resulted in the conclusion that human health and the environment counted so much that the use of lead in gasoline was phased out.[46] For other questions, such as the use of lead in batteries, the environment appears in today's world to count in a way that indicates caution, but not prohibition, of its use.

Economic theory provides one framework for how much the environment should count—up to the point where all of the additional costs of environmental protection are equated with all of the additional benefits of that protection. But the economic framework does not enclose a finished canvas. Lack of knowledge of natural and social scientific causes and effects leaves many parts of the canvas blank. Gaps exist in the economic framework itself, such as improved understanding of decisionmaking in uncertain situations, the role of large and discrete changes in the economy or the environment, and more fundamentally, how to aggregate and measure changes in the wellbeing of society.

Just as the framework and the canvas are still evolving, so too are the tools for making the environment count. This chapter has described several examples of tools that already contribute, or could increasingly contribute, to harnessing the power of the marketplace to prevent pollution, clean up pollution, or manage wisely the nation's stock of natural resources. To summarize, those tools include the following:

- Cost-saving incentives stemming from regulations such as those for waste disposal;
- Marketable pollution allowances such as those for sulfur dioxide emissions;
- Taxes such as those for chlorofluorocarbons;

- Incentives to account for and to avoid liability;
- Modifications to natural resource auctions;
- Technical assistance, education, research, and development; and
- Better national income accounting to reflect natural resource depletion.

Other tools to harness the power of the marketplace are an active part of the evolving policy debate to integrate the environment and economics. That debate holds great promise to further reduce the costs of achieving environmental goals.[47]

For the near term, vigorous enforcement of environmental statutes will continue to be necessary and will define the background conditions for the operation of the economy. Some regulations are increasingly seen as providing indirect signals and incentives for technological change to prevent pollution. Other regulations use economic approaches to reduce the direct costs of achieving environmental quality goals.

Enforcement of liability claims and guidelines that define best business practices, whether in accounting or engineering, will be crucial to integrating economics and the environment. Public-private partnerships can create opportunities to improve the provision of environmental services and exploit the strengths of the private sector. A relatively stable legal and regulatory climate will help to decrease the risks of investment in cleaner, more advanced technologies, and more generally, foster the creative chaos that is the capitalist system.

But at the bottom line, individual businesses and consumers will remain the driving forces in making the environment count and deciding how to keep the scorecard. They will determine, along with the poets, whether the trees and the stones and the rest of the natural world "are worth it."

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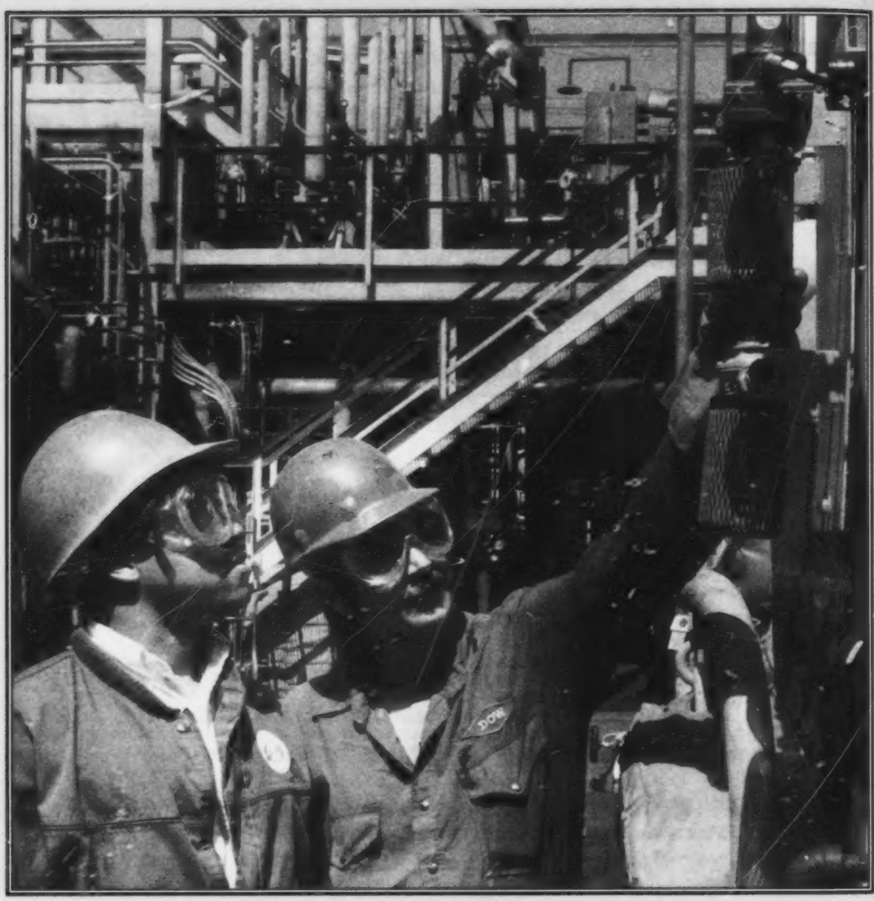


Pollution prevention can benefit both the environment and the bottom line. Progress is possible with available technology, and research and development are increasing prevention options. Institutional commitment and a systems management approach are also key elements. In the words of CEQ Chairman Michael Deland:

> ***The time has come to look not just to the discharge end of the pipe but to scrutinize the production process itself. Treating pollution as inevitable is a backward concept in a competitive world.***

CHAPTER 3

TECHNOLOGY FOR POLLUTION PREVENTION

America's environmental strategy is undergoing a dramatic transformation. While the National Environmental Policy Act (NEPA) set the goal 21 years ago of creating "a productive harmony" between humans and nature, the nation continues to struggle against pollution and to seek new ways to combat it. The most promising of these new approaches is *pollution prevention*.

In the early 1970s the federal government adopted a series of pollution control laws aimed at media-specific problems (air, water, waste disposal) and a regulatory framework of specific goals, deadlines, and technological controls. Today, while the regulatory framework has accomplished significant pollution reductions, such "command-and-control" measures are often viewed as inadequate and needlessly expensive for each increment of improvement.

Continued progress requires a broader way of thinking about environmental policy, one that encompasses concerns about economic development and global competitiveness, technological innovation, and a wider variety of environmental risks. That new way of thinking is pollution prevention. Stated simply, pollution prevention means to reduce or eliminate the amount and toxicity of society's pollutants *at their source*. It contrasts with end-of-pipe treatment of wastes already generated.

The concept of prevention is not new; on the contrary, a 1966 report of the House Subcommittee on Science, Research, and Development stated that "the concept of . . . maximum waste prevention in the first place, and salvage of used materials, is an objective which would decrease the need for cleaning up the environment later on."[1] Nonetheless, the Congress was eager to get on with environmental cleanup and determined that "the obvious and obnoxious cases of pollution should be eliminated as soon as time and money required for construction of abatement facilities will permit."[2] It was toward that end that the current regulatory framework was built and large quantities of technology and management expertise were applied. Pollution prevention remains to this day a relatively new way of thinking for those accustomed to pollution control.

Regardless of which environmental strategy is employed, progress relies on effective use of the nation's managerial and technological resources. Fortunately, the technology for pollution prevention is not necessarily new. Likewise, the *systems approach*—a holistic, life-cycle approach that defines problems, establishes objectives, generates options, analyzes and selects solutions, and then continually assesses results—has been in use for decades. What *is* new in recent years is that such forces as economic competition, regulatory costs, and public concern, in concert with the systems approach, are driving institutional change toward pollution prevention strategies.

The Logic of Pollution Prevention

Pollution prevention places priority on source reduction in a hierarchy of options for addressing pollutant wastes: first, source reduction; second, recycling and reuse; third, treatment; and fourth, disposal.[3] All of these options are valid: the current state of economic and environmental knowledge supports using a mix of them. Nonetheless, source reduction remains the preferred approach for the protection of environmental quality for a variety of reasons.

- Individual pollutant controls do not always address cross-media impacts; for example, the sludge created by treatment of air or water pollution becomes a waste disposal problem.
- Both nonpoint pollution sources, such as urban stormwater runoff, and small, dispersed point sources, such as commercial establishments, contribute a significant portion of society's harmful pollutants. However, such sources are difficult to regulate through traditional large-source emission standards.

- Pollution prevention embodies efficiency in resource and energy use and, therefore, in most cases, offers a more cost-effective solution in the long-run than direct regulation. This is particularly relevant at a time when economic competitiveness is a national priority and total pollution control costs to businesses and public agencies have grown to $115 billion annually.[4]

A Broad Look at Pollution

A broad definition of pollution encompasses both economic waste and harm to the environment:

> *Pollution is the undesirable change in the physical, chemical or biological characteristics of our air, land, and water that may or will harmfully affect human life or that of other desirable species, our industrial processes, living conditions, or cultural assets; or that may or will waste or deteriorate our raw material resources.*[5]

From the perspective of the producer in the total economic system, "a waste is a nonproductive stream of material or energy for which the cost of recovery, collection, and transport . . . to another use is greater than the value as an input."[6] For society, materials and energy become wastes when it is less costly to discard them into the environment than to put them to other uses. Such wastes are termed *residuals*.

The society at large does incur costs when residuals are discarded into the environment, although the market frequently does not reflect those costs or the value of reusing residuals. But improved methods of accounting for such costs (see Chapter 2, "Making the Environment Count") are beginning to redress the oversight. For example, regulations imposing pollution control costs on waste generators have created economic incentives to prevent pollution. Likewise, many producers now find they can increase production efficiency and achieve their economic self-interest more effectively by reducing nonproductive residuals—in other words, by preventing pollution.

Table 3-1 identifies residuals from key sectors, while Figure 3-1 charts the flow of wastes in the total economic system. Although all contributors are not identified, particularly in the manufacturing sector where modern processes create hundreds of residuals, the listings demonstrate the spectrum of wastes across society and illustrate the broad target for pollution prevention efforts.

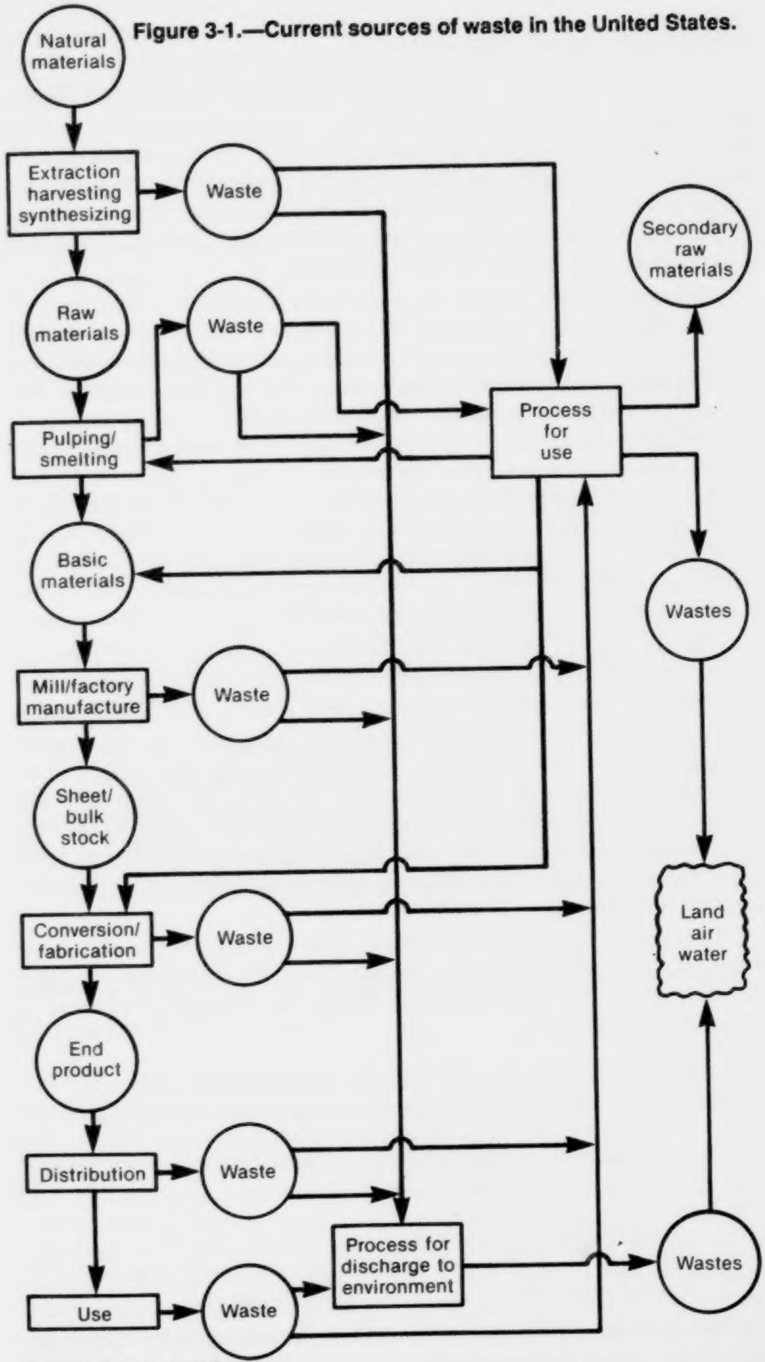
Table 3-1.—Selected list of residuals generated in the United States, excluding spills.

SOURCE	RESIDUALS
Mining	Overburden, tailings, leachate, surface runoff, wind-entrained particles.
Agricultural operations	Crop sediment, pesticides, and nutrients in runoff; nitrogenous material and pesticides in leachate to groundwater; wind-blown sediment; wind-transported pesticides; volatilized pesticides; pesticide and fertilizer containers.
Silvicultural operations	Suspended sediment and pesticides in surface runoff, wind-transported pesticides, slash.
Transportation	CO, HC, NOx, particulates, particles from tires deposited on ground surface, oil, liquids discharged from boats, salt/sand from snow removal, tires, used oil, batteries, obsolete vehicles.
Residential	CO, NOx, SO2, TSP, and ash (depending on fuel and heating system); white goods, bulky materials, septage, food wastes, yard wastes, aluminum (cans, wrap), steel cans, glass, plastic (containers, wrap, trays, utensils), household batteries, junk mail, liquid residuals.
Energy consumption	CO, NOx, SO2, TSP, ash (fly, bottom, scrubber sludge), water treatment chemicals, suspended solids, boiler and cooling system blowdown.
Manufacturing	BOD5, TSS, priority pollutants (liquid), food wastes, yard wastes, metals, wood, glass, plastic, aluminum cans, various solid wastes, process/product combinations peculiar to manufacturing, such as carpet trimmings, cuttings from sheeting in manufacture of mobile homes, gaseous residuals (from heating/air conditioning/process steam/electricity generation), water treatment sludge, wastewater treatment sludge, scrubber sludge.
Commercial	BOD5, TSS, food wastes, yard wastes, glass, plastic, aluminum cans, bulky goods, gaseous residuals from heating/air conditioning.
Institutional	BOD5, TSS, same as commercial plus those peculiar to activities, such as infectious wastes from hospitals/nursing homes, low-level radioactive materials from hospitals/research labs.
Municipal	Street sweepings, sediment from debris basins, dead animals, grass clippings/brush and tree trimming (from public parks/streets/public building areas), water treatment sludge, wastewater treatment sludge, septage.
Construction	Wood (lumber and tree segments), bricks, dirt, stamps, fixtures, metals, plastic, food wastes, and food containers.

Note: BOD5 = 5-day biological oxygen demand, CO = carbon monoxide, HC = hydrocarbons, NOx = nitrous oxides, SO2 = sulfur dioxide, TSP = total suspended particulates, TSS = total suspended solids.
Source: From Bower, B.T., "Economic, engineering, and policy options for waste reduction," page 4 in National Research Council, Committee on Opportunities in Applied Environmental Research and Development, *Waste Reduction: Research Needs in Applied Social Sciences—A Workshop Report*, (Washington, DC: NRC, 1990).

Some waste is virtually inescapable in the use of materials and energy so, from the ecological perspective, the choice of materials and technologies used in the economic system should attempt to minimize the quantity of residuals harmful to the life-sustaining elements of the natural environment. Indeed, the long-range goal should be to discard only the quantity and quality of residuals that can be sustained by the environment's natural self-cleansing capacity. Useful products can also become wastes over time as they wear out or are discarded, causing pollution problems identical to those of waste residuals.[7]

Figure 3-1.—Current sources of waste in the United States.


Natural materials
Extraction harvesting synthesizing
Waste
Raw materials
Waste
Pulping/ smelting
Basic materials
Mill/factory manufacture
Waste
Sheet/ bulk stock
Conversion/ fabrication
Waste
End product
Distribution
Waste
Use
Waste
Process for discharge to environment
Process for use
Secondary raw materials
Wastes
Land air water
Wastes

Source: Bower, page 2.

Scope of This Chapter

The 1989 Annual Report of the President's Council on Environmental Quality (CEQ) offered a national overview of pollution prevention efforts. It developed the concept in historical perspective as a long-underused supplement to pollution control. Further, the report described prevention strategies in manufacturing, energy, transportation, agriculture, and households and discussed nascent federal, state, and local programs designed to prevent pollution.

This year's CEQ report updates the subject from a pragmatic perspective. Technology—defined as the application of science to specific objectives, especially industrial or commercial objectives—includes both hardware and organizational factors. Hence, "Technology for Pollution Prevention" explores the many ways that scientists, engineers, federal policymakers, and corporate managers are applying new methods and hardware to integrate environmental objectives into their traditional missions. Conceptually, pollution prevention technology is *all* technology, designed and operated to make the environment count in the design and operation of complex production systems. And since technology includes methods as well as equipment, the emphasis will be on the systems approach taken by managers who prevent pollution.

For purposes of limiting this discussion to a manageable scope and examining areas of greatest current activity, this chapter focuses on industrial activities in the private and public sectors. The private-sector section is primarily concerned with pollution prevention in manufacturing and electric power production. The public-sector discussion focuses on two federal agencies with substantial industrial activities—the Departments of Energy and Defense—and the prevention initiatives of the U.S. Environmental Protection Agency (EPA) and other federal agencies. Programs in other institutional settings—legislatures, state agencies, and academia—are also discussed.

In addition to the 1989 CEQ report, numerous other useful publications are cited throughout this chapter. Of special note is EPA's *Pollution Prevention Strategy*, which discusses the prevention concept in several social sectors:[8]

- Manufacturing and Chemicals—including changes in production processes, raw material inputs, and outputs;
- Agriculture—including low-input farming methods and soil conservation; and
- Energy and Transportation—including increasing efficiency in production and end-use, and increasing reliance on inherently "clean" energy sources.

The EPA strategy provides direction within the agency to reorient existing programs and targets specific chemicals from the manufacturing sector for prevention strategies. EPA has set a goal of reducing national emissions of these chemicals by 33 percent by the end of 1992 and at least 50 percent by the end of 1995.

Technology Update

As this section surveys developments in technology, three major themes emerge:

- **Current Focus: Industrial Toxics.** Although the opportunities for pollution prevention range across many economic sectors, current efforts are focused largely on toxic industrial wastes defined as extremely hazardous under government regulations.
- **Energy Efficiency.** Energy is a major component of the economy, and a correlation exists between the efficiency with which the nation uses energy and energy-related pollution. In short, to improve energy efficiency is to prevent pollution. Although U.S. energy efficiency has already improved by about a third since 1973, spurred by energy price changes and use of new technologies,[9] opportunities exist for additional efficiency gains.
- **Systemic Approach.** Pollution prevention technology must be employed as part of a systemic approach that focuses not just on the parts but on the workings of an internally consistent whole. The systems mindset recognizes the many elements of economic competitiveness and the need to incorporate both existing and emerging technologies.

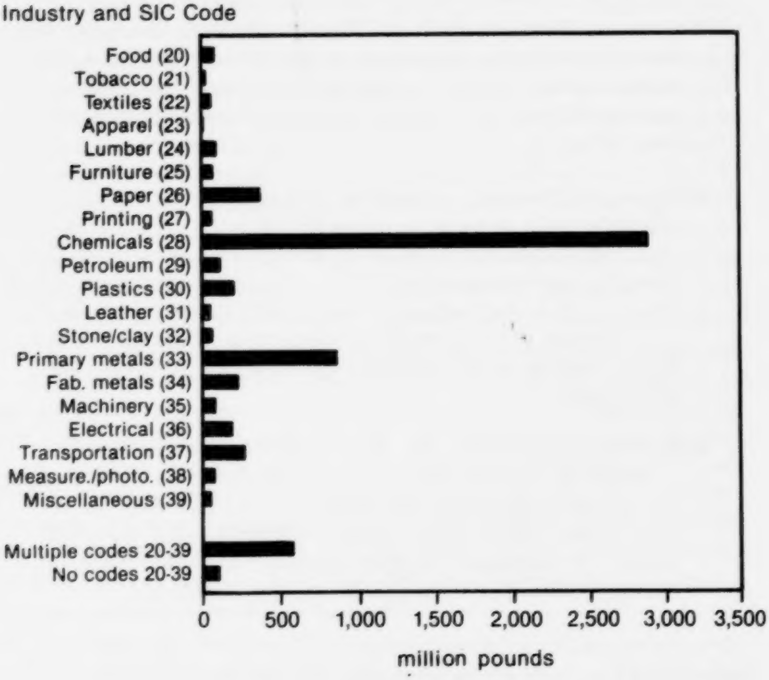
Measuring the Problem: The Toxics Release Inventory

While the nation's many pollution problems can be addressed by prevention efforts, the emphasis to date has been on reducing industrial toxics. Currently, the best information on this subject is the *Toxics Release Inventory (TRI)*, published by EPA. Title III of the 1986 Superfund Amendments, also known as The Emergency Planning and Community Right-to-Know Act, requires the inventory. In 1990 EPA published the TRI for the second time, covering 1988 releases of all manufacturing facilities in the United States that produced, imported, or processed 50,000 pounds or more of any of 302 individual toxic chemicals and/or 20 categories of chemicals listed for reporting by EPA and/or used in any other manner 10,000 pounds or more of these 322

TRI chemicals. Such chemicals vary widely in toxicity and in the frequency, amounts, and industrial processes in which they are used.[10]

Table 3-2 and the accompanying Figure 3-2 present toxic releases by industry and by discharge medium. Nearly 20,000 facilities reported over six billion pounds of chemical wastes released to the environment or transferred off-site.

Figure 3-2.—Toxics Release Inventory (TRI) releases and transfers, 1988.



Source: U.S. Environmental Protection Agency, *Toxics in the Community*, (Washington, DC: U.S. Government Printing Office, September 1990), page 146.

The TRI continues to evolve as a prime indicator of waste generation and as a focus for pollution prevention efforts. TRI data include releases to all environmental media—air, water, and land—in contrast to most previous single-media data collection efforts, and TRI was designed from the outset to be publicly accessible by computer modem.

However, the TRI has limitations. It describes only the emissions of manufacturers, which make up only a fraction of the total emissions of a range of small, dispersed sources such as motor vehicles, solid waste facilities, and small businesses that use hazardous chemicals.

Table 3-2.—Toxics release inventory (TRI) facilities and forms, by industry, 1988.

TRI TOTAL RANK*	INDUSTRY	SIC CODE**	FACILITIES	FORMS	AIR	SURFACE WATER	LAND	UNDER-GROUND	PUBLIC SEWAGE	OFF-SITE TOTAL	TOTAL RELEASES AND TRANSFERS	
			----- number -----		----------	----------	----------	pounds	----------	----------	----------	%
11	Food	20	1,452	2,649	13,716,106	3,633,426	12,454,502	1,017,909	39,117,332	2,962,616	72,901,891	1.17
21	Tobacco	21	19	62	13,820,462	118,812	14,751	0	791,940	312,982	15,058,947	0.24
15	Textiles	22	401	890	35,617,602	4,693,758	191,896	0	15,274,101	3,547,714	59,325,071	0.95
22	Apparel	23	29	49	1,019,201	250	40,599	0	692,897	166,748	1,919,695	0.03
19	Lumber	24	616	1,719	27,813,245	101,014	198,009	0	952,592	4,303,183	33,368,043	0.53
13	Furniture	25	397	1,556	56,894,704	1,850	56,511	0	390,551	5,451,673	62,795,289	1.01
4	Paper	26	587	2,328	202,210,446	86,518,400	9,925,423	0	39,743,943	31,944,839	370,343,051	5.93
14	Printing	27	313	623	50,423,807	35,150	316	40,000	3,460,704	6,581,949	60,541,926	0.97
1	Chemicals	28	3,838	20,332	754,922,471	228,105,753	164,564,318	973,706,836	323,874,071	438,305,845	2,883,479,294	46.20
9	Petroleum	29	364	3,053	54,989,933	3,471,886	3,153,767	19,846,879	13,060,813	9,713,429	104,236,707	1.67
7	Plastics	30	1,293	3,213	158,832,600	733,598	155,662	3,004	4,957,837	24,443,360	189,126,061	3.03
17	Leather	31	132	372	14,255,347	680,505	353,215	0	20,340,615	2,176,552	37,806,234	0.61
16	Stone/clay	32	559	1,315	23,283,963	874,242	2,029,808	6,580,250	1,294,091	21,120,356	55,182,710	0.88
2	Primary metals	33	1,380	5,446	232,958,571	18,987,700	277,003,090	41,020,432	19,088,232	268,808,482	857,866,507	13.75
6	Fabricated metals	34	2,579	7,860	117,524,318	1,518,379	4,742,417	286,120	18,342,883	72,698,383	215,112,500	3.45
10	Machinery	35	870	2,315	51,754,691	548,021	257,368	52,800	2,993,295	19,725,887	75,332,062	1.21
8	Electrical	36	1,578	5,047	115,198,789	714,367	1,454,389	43,720	18,711,626	46,261,903	182,384,794	2.92
5	Transportation	37	1,054	4,447	201,297,144	331,889	1,256,795	21,384	7,502,020	50,770,863	261,180,095	4.18
12	Measure/photo.	38	344	1,000	45,076,520	685,863	490,993	250	5,415,110	12,698,912	64,367,648	1.03
8	Miscellaneous	39	372	946	26,171,054	54,173	304,149	0	452,222	9,061,758	36,043,356	0.58
3	Mult. codes 20–39		1,303	5,133	217,850,529	8,547,184	80,320,516	172,724,324	30,813,971	69,259,997	579,516,521	9.29
20	No codes 20–39		282	776	11,938,600	1,238,018	2,588,388	0	3,280,462	4,096,876	23,142,344	0.37
	Total		19,762	71,131	2,427,570,103	361,594,238	561,556,882	1,215,343,908	570,551,308	1,104,414,307	6,241,030,746	100.0

*Toxics Release Inventory ranking by pounds of emissions, with 1 = greatest volume of emissions.
**SIC = Standard Industrial Classification.
Source: U.S. Environmental Protection Agency, *Toxics in the Community*, (Washington, DC: U.S. Government Printing Office, September 1990), pages 56–57.

TRI describes only toxic emissions, which are a fraction of the broader waste problem summarized in Table 3-1, and it is limited to those toxic chemicals listed by EPA. Perhaps most significantly, TRI shows emissions or transfers *after* treatment, rather than the pollution generation data needed for prevention analysis. On the 1988 inventory form, only 10 percent of the respondents completed a voluntary section requesting data on waste minimization.[11] This statistic led Congress to make reporting on waste minimization mandatory in the future under the Pollution Prevention Act of 1990. Such additional data will help refine the nation's evolving effort to prevent industrial toxics pollution.

The Role of Corporate Management

Industrial pollution prevention technology must be integrated into a system that includes organization, operating procedures, and investment dollars. Corporate management plays the key role in developing a comprehensive program that reaches all levels of a company. The most successful organizations at preventing pollution and minimizing waste overall are those that employ multifaceted programs with the following elements:[12]

- A formal commitment by management to the pollution prevention ethic, translated by management and employees into a company wide commitment in all divisions of the organization;
- Explicit program scope and goals;
- Accurate waste and cost accounting to assess costs, benefits, and programs (see Chapter 2);
- Periodic pollution prevention opportunity assessments to identify opportunities for improvement and evaluate progress;
- Periodic self-evaluation that keeps programs on track; and
- Educational workshops and training materials that share technical information and experience with affiliates, customers, and suppliers.

The following examples illustrate elements of the comprehensive systems approach for pollution prevention. The examples demonstrate the entire hierarchy of options: source reduction, recycling, and treatment and disposal, as appropriate. Although these programs all represent integrated approaches, each one highlights specific aspects of the essential elements just outlined.

CASE STUDIES

Company-wide Commitment Involves Employees: The 3M Company

For successful pollution prevention, commitment of top management is essential but so is that of the entire workforce. Effective managers educate not only themselves but also their employees on environmental risks to the community, and they develop a two-way dialogue concerning ideas and progress toward reducing pollution. 3M established a comprehensive Pollution Prevention Pays (3P) program in 1975 to minimize pollution at the source.[13] The program is directed at the company's 5,000 technical employees who are responsible for product formulation, process, design, manufacturing operations, and recycling. Employees are asked to implement pollution prevention concepts in the daily activities of their specialty areas and then submit accomplishments to the 3P coordinating committee for review. Their efforts are judged for environmental benefit, cost savings, and technical achievement. Superior efforts are recognized in presentations by senior management before fellow employees, in awards, and often in private dinners. Such recognition raises employee enthusiasm and participation.

Since 1975 3M has recognized more than 2,400 3P projects that have resulted in cost savings of more than $480 million. These projects have eliminated more than 120,000 tons of air pollutants, 16,000 tons of water pollutants, 400,000 tons of sludge, and 1.6 billion gallons of wastewater.

Company-wide Commitment Across Activities: Dow Chemical Company

The Dow Chemical Company, a worldwide manufacturer of more than 2,000 products, has a diverse and comprehensive approach to the environment. The pollution policy hierarchy is stressed, with pollution prevention the first priority. U.S. operations are conducted under a program called WRAP—Waste Reduction Always Pays.

Dow is reducing water emissions by recycling wastewater, developing more efficient water treatment technologies, and upgrading spill prevention and containment systems. The company also has reduced total air emissions from its U.S. plants by more than 50 percent since 1985. Direct savings are an additional payoff for pollution prevention. For example, Dow invested $12 million in 47 waste reduction projects in Louisiana in 1988 and 1989. On average, the projects paid for themselves in just ten months.[14]

The approach extends to other Dow activities. A new chemical plant in Taiwan has been designed for zero process wastewater discharge. Among a range of recycling initiatives, Dow has formed, with seven other manufacturers, the National Polystyrene Recycling Company with a goal of recycling 25 percent (250 million pounds) of the polystyrene used in food service and packaging applications in the United States every year. In energy, Dow is the world's largest producer of cogenerated power and claims efficiency that is 20 percent greater than conventional fossil fuel plants.

Explicit Program Scope and Goals: Chevron USA Inc.

Chevron's Save Money and Reduce Toxics (SMART) program, established in 1987, encourages each division to set goals and develop a plan tailored to its individual problems, with an overall goal of 65-percent toxics reduction by 1992. Managers are evaluated on their ability to meet environmental goals. In SMART's first year, hazardous waste disposal was reduced from 135,000 to 76,000 tons and the company's waste disposal bill dropped almost $4 million.[15]

Pollution Prevention Opportunity Assessment: AMOCO Corporation

The first action in determining the technology needed for pollution prevention is to define the problem by performing a pollution prevention assessment. Basic steps include planning the effort, assessing, evaluating results, and implementing the selected options.[16] Such an effort develops detailed knowledge of the system under examination and generates the opportunities for change to prevent pollution.

In 1989 AMOCO proposed a joint project with EPA to study the firm's Yorktown, Virginia, refinery, which began operations in 1956 and has a capacity of 53,000 barrels per day. The joint project attempts to properly inventory emissions, develop prevention options, rank options, and determine impediments to implementation. AMOCO contributes 70 percent of the $1.8 million budget, with EPA providing the remainder. Almost one-half of the costs are for data collection.[17] In addition to studying the facility's options, EPA's objective was to assess the feasibility of integrated regulatory permits, using a cross-media approach.[18]

Designing a comprehensive and accurate emission data-measuring system was a technical challenge in a plant not designed to facilitate such assessment. As one AMOCO official associated with the project said, "Pollution prevention is not for the merely enthusiastic."[19] The assessment involved air emission modeling with appropriate site sampling to validate model predictions, 19 surface water sampling locations, an extensive network of groundwater wells, 33 solid waste sampling locations, and a survey of public perceptions. New sampling technologies had to be integrated with those in place. Throughout the ongoing project, the team hopes to track pollutants through the various media and develop true cross-media pollution prevention options, including a procedure for cross-media permitting.[20]

Self-Appraisal: Monsanto Company

The comprehensive waste reduction program initiated by Monsanto in 1982 achieved 50 percent reductions by 1987. A self-evaluation made in 1988, however, found that achievements were increasingly the result of downsizing—the termination or sale of businesses. Aware that this trend would not continue, the company developed a new effort to focus on multimedia emissions. The programs that emerged are intended to reduce hazardous air emissions 90 percent by 1992 and nonhazardous chemicals by 50 to 70 percent over a five-to-eight-year time frame.[21]

Technology Transfer: AT&T Company and The Boeing Company

Sharing knowledge and experience are key to establishing consistent pollution prevention programs in industries across the nation. AT&T's multifaceted environmental program includes not only employee education and on-site recycling but also program assistance to other industries. Hundreds of companies have sought AT&T's assistance in setting up their own programs.[22]

The Boeing Company has an Office of Environmental Affairs which, among other things, arranges technology transfer among companies. The communication between Boeing divisions, other aerospace companies, and outside interests are an element of the company's success in guiding its own waste minimization program toward fewer hazardous wastes.[23]

Promoting a Wider Commitment: Chemical Manufacturers Association

An increasing number of associations are moving in support of pollution prevention by setting goals and sharing information among their memberships. In 1990 the Chemical Manufacturers Association (CMA) adopted a mandatory membership requirement to abide by ten guiding principles for "Responsible Care." Members must adopt a waste management hierarchy that gives priority to source reduction, followed by recycle/reuse, and only then by treatment. CMA has also instituted mandatory reporting by member companies of their progress in waste minimization.[24] The association publishes the *Waste Minimization Resource Manual*, which provides guidance on starting and maintaining a waste minimization program, describes how economic incentives work, and outlines other aspects of the program such as tracking and measuring progress. CMA also publishes a newsletter to update members on advances in waste minimization within the chemical industry.

The Production Process: Generic Pollution Prevention Techniques

American industry is a mosaic of thousands of products and production processes. Economic life reflects the decentralized free enterprise system. It follows logically that technical progress toward pollution prevention is also decentralized, driven by economic considerations, and frequently specific to one of thousands of different industrial processes. If any generalization is possible, it would be to characterize current pollution prevention technology as employing conventional engineering approaches. It is to be expected that as priority shifts from treatment and control to prevention, engineers first will employ available technology to achieve their objectives. In the future, however, designs will become more innovative.

Industrial pollution prevention techniques can be understood by observing the path of material as it passes through an industrial site.[25] Even before materials arrive on site, decisions can be made to avoid toxic materials when less toxic substitutes exist. When material arrives at a facility, it is handled and stored prior to use; material may also be stored during stages of the production process. At this point, the objective is to prevent spillage, evaporation from containers or conduits, or shelf-life expirations. Better technology might consist of tighter inventory practices, sealless pumps, welded rather than flanged joints, bellows seal valves, floating roofs on storage tanks, and rolling covers versus hinged covers on openings. These techniques are not exotic, but they could lead to large replacement costs if a company has many locations where leakage can occur. Conversely, they could provide large economic benefits by reducing the loss of valuable materials.

At the next stage, materials are processed, frequently in the presence of heat, pressure, and/or catalysts, to form products. As materials are reacted, combined, shaped, painted, plated, and polished, excess materials not required for subsequent stages become waste, frequently in combination with toxic solvents used to cleanse the excess from the product. The company disposes of these wastes either by recycling them into productive reuse or by discharging them into the air, water, or land. Often costly treatment is required to reduce the toxicity or pollutant impact of the waste discharge before final disposal. These liquid, solid, or gaseous residues at each stage of the production process are the source of toxic waste problems.

Pollution can be prevented in many ways specific to particular processes, but the following general fixes are applicable to many of them:

- **Process Controls.** The precision of temperature and pressure applications as materials are reacted and handled can significantly alter the formation of toxics. Improvements may include better control mechanisms to meter materials into mixtures; better sensors to measure reactions; more precise methods of applying heat such as lasers; and computer assists to automate the activity.

- **Cleaning Processes.** The cleaning of parts, equipment, and storage containers is a significant source of contamination. Toxic deposits are common on equipment walls. The use of solvents to remove such contamination creates two problems: disposal of the contaminants and emissions from the cleaning process itself. Some fixes include the use of water-based cleansers versus toxic solvents, nonstick liners on equipment walls, nitrogen blankets to inhibit oxidation-induced corrosion, and such solvent-minimizing techniques as high pressure nozzles for water rinse-out.

- **Chemical Catalysts.** Catalysts facilitate chemical reactions and are a fruitful area of pollution prevention research. Better catalysts and better ways to replenish or recycle them would induce more complete reactions and less waste. Substitution of feedstock materials that interact better with existing catalysts can accomplish the same objective.

- **Coating and Painting.** For this common source of toxic waste, technical improvements include better spray equipment, such as electrostatic systems and robots, and alternatives to solvents, such as bead blasting.

- **Segregating and Separating Wastes.** A drop of pollutant in a pure solution creates a container of pollution. Keeping wastes and nonwastes segregated reduces the quantity of waste that must be handled. Various technical fixes provide more precise and reliable separation of materials unavoidably mixed together in a waste stream by taking advantage of different characteristics of materials, such as boiling or freezing points, density, and solubility. Separation techniques such as distillation, membranes, evaporation, filtration, and centrifugation convert mixed wastes back to their constituent parts. Simple in principle, these processes become high-tech in the precision with which they are applied to facilitate other options in the hierarchy such as recycling, treatment, and disposal.

- **Support Activities.** Garages, motor pools, powerhouses, boilers, and laboratories—all have wastes that cannot be overlooked.

- **Materials and Product Substitutions.** The issues involved here are complex and include economics and consumer preferences as well as technology. Obviously, the use of less toxic materials in production is an effective way to prevent pollution in a decentralized society. Scientists and engineers are actively evaluating and measuring material toxicity and developing safer materials. Likewise, the life-cycle approach requires that products be designed with an awareness of implications from the raw material stage through final disposal. For example, the debate over changing fast-food packaging involves substitutes for existing packaging. Another example is the near total elimination of lead in the air resulting from its removal from gasoline.

In summary, pollution prevention technology is a combination of efficient operational procedures, product designs that use materials with minimum waste and toxic byproducts, and technical processes that are precisely sensed, monitored, and controlled. Much of the technology to prevent pollution is available now, and frequently it is relatively simple. Among current techniques, those associated with solvent control and coating/painting are the winners for sheer quantity of actions underway. Large savings accrue when capital investments are made, but smaller process and maintenance actions can add significantly to overall savings.

Pollution prevention techniques apply equally well to small businesses and large ones. Since such techniques often employ existing technology, the special challenge for small businesses is gathering information and financing first costs.

S.C. Delaney, EPA

Pollution prevention research is bringing new technologies and methods to the fore.

Research Needs

Innumerable research and development possibilities are specific to individual industries and proprietary processes, but generic research needs exist for pollution prevention, such as the following:[26]

- **Understanding Key Chemicals.** Research on the characteristics of toxic industrial chemicals will lead to a better understanding of how they accomplish their purposes, facilitating substitution with less toxic chemicals. Examples include understanding chlorofluorocarbons, which are superior cleaning agents on electronic surfaces, as well as organic solvents, which are superior cleansers in general; understanding chemical and biological fouling and other surface phenomena that cause cleaning needs in equipment; understanding reaction chains that yield unreacted elements, such as trace contaminants in polymer production, or processes that yield undesirable intermediate products such as dioxin; and understanding processing aids such as surface coatings or lubricants.

- **Revising Design Criteria to Emphasize Waste Minimization.** Examples of research in this area are the painting process, which could be more efficient; metal bonding and composite processes; and the transfer of dyes to fabrics, which uses excessive amounts of inorganic salts. The lay-down process that converts wood fiber to paper is inefficient, and the role of dilutants—air, water, and other fluids—needs study because they impede the recovery of materials. Containers and parts could be redesigned to reduce residue buildup.

- **Recycling.** Research could show how products can be designed for resource recovery. For example, primary manufactured goods could be designed with easily separable components to facilitate recovery; filters and exchange media used in pollution control could be made recoverable; and biological processes could be harnessed in conjunction with thoughtful design to degrade wastes into usable products.

- **Intractable Wastes.** Some research focuses on perennial waste problems for which no cost-effective solution has emerged. For example, water in sludge inhibits chemical and energy recovery, and dewatering techniques need to be developed. The list of "intractable" wastes is long.

- **Social, Economic, and Health Factors**. Research could address the range of social reactions to pollution prevention initiatives. In addition to questions of convenience and practicality, it is difficult to estimate accurately the costs of many pollution prevention techniques.

The overall needs in pollution prevention research range from looking at old problems through the lens of waste minimization, finding ways to apply new high technology, addressing tough, familiar materials problems, and learning more about the human and social factors involved in prevention. Science is challenged by the pollution prevention concept, but the incentives to develop new techniques are strong. The alternatives to pollution prevention are increasing economic costs of waste disposal, increased liability and regulation, and increasingly marginal gains toward a quality environment.

Energy Technology

Energy is a major component of the economy; its production and use are a major source of pollution. Advancing pollution prevention requires that the nation address the technological and economic issues of a complex, dynamic energy market.

Predictions of the future depend heavily on underlying assumptions, but a comprehensive study of the American people's energy future[27] makes several projections:

- New electricity generation capacity will be needed in the United States, even if conservation and efficiency are pursued as aggressively as possible;
- Energy efficiency gains can and should be accelerated;
- Meeting increased demand will require a growing role for renewable energy sources like solar and wind power;
- Natural gas use is likely to grow and could serve as a bridge fuel until more environmentally acceptable fuels are available;
- Nuclear power may continue to serve as a reliable and cost-competitive source of electricity if issues of safety, cost, permitting, and waste disposal are successfully addressed; and
- Coal, which is abundant and relatively economical, is likely to continue to be a major source of power generation.

A long-term view is essential because energy capital investments made today may not produce power for a decade, given long lead times for design, permitting, and construction. Once in operation, new energy facilities will last well into the twenty-first century.

Energy technologies pertaining to pollution prevention fall into three categories:

- **Clean Fuels.** Energy production creates less pollution if the energy sources are inherently cleaner, such as renewable solar or wind power, or, in the case of fossil fuels, if they contain less sulfur (reducing sulfur dioxide formation), produce less combustion residue (ash), or emit less carbon per unit of energy.
- **Cleaner Combustion.** Combustion of fuel produces fewer harmful emissions if new combustion technology is inherently

cleaner. By reducing the need for pollutant treatment or by improving efficiency, the result can be fewer unwanted emissions per unit of output.

- **Efficient End Use.** Emissions are held down if end-use sectors become more efficient, thereby demanding less energy and creating less pollution.

Energy Production

A basic energy flow diagram (Figure 3-3) shows that the United States relies heavily on fossil fuels.

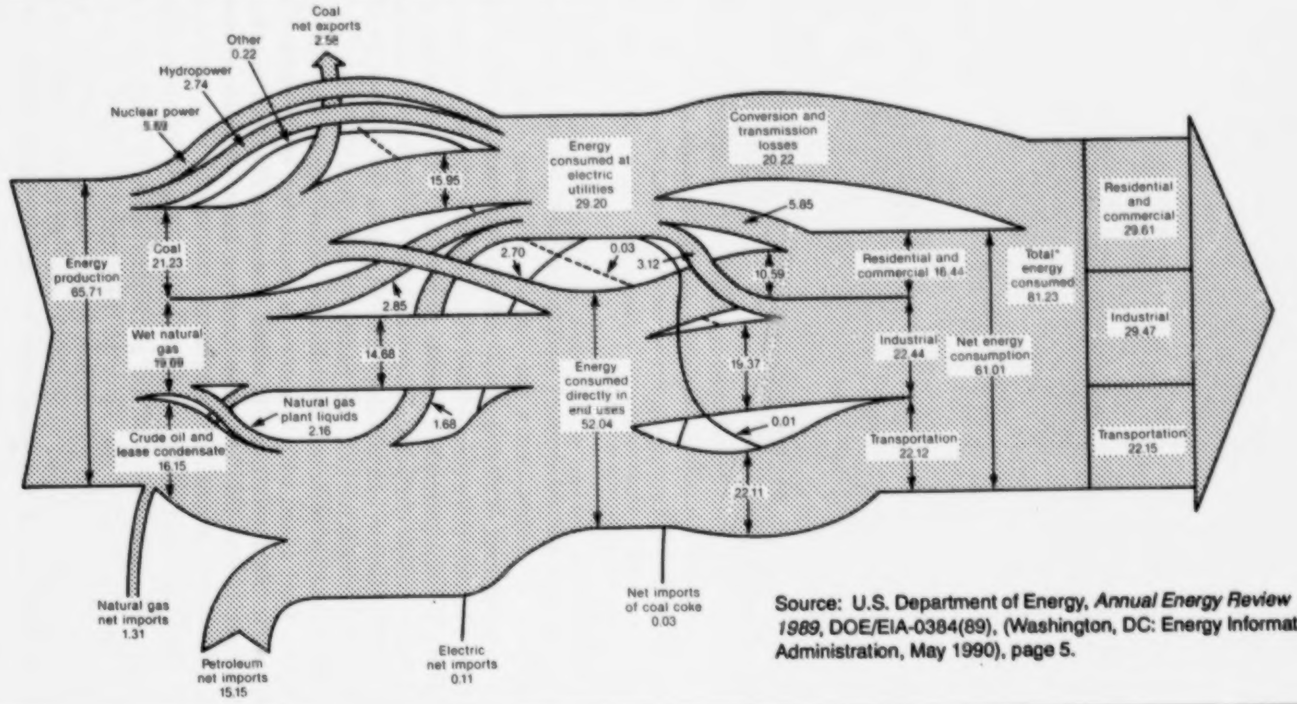
Nearly 90 percent of the primary energy the nation consumes is fossil—petroleum, natural gas, and coal. Fossil fuels are the primary source of sulfur dioxide, nitrogen oxides, and carbon monoxide, "criteria pollutants" targeted by the Clean Air Act. Fossil fuel combustion is also a leading source of emissions of carbon dioxide, which along with methane, nitrogen oxides, chlorofluorocarbons, and others are greenhouse gases.

As the nation and the world seek a sustainable energy-environmental future, nonfossil fuel sources are attractive options. However, the economics of renewables such as photovoltaics, while favorable in some locations, are unlikely to allow for large substitutions for fossil fuels in the near term. Nor has nuclear technology, another nonfossil alternative, overcome numerous obstacles, despite promising research on advanced reactors that incorporate passive safety or intrinsic safety features and despite efforts to develop long-term nuclear waste disposal. Both renewable and nuclear alternatives will continue to be priorities for research, development, and incremental additions where justifiable. But in the immediate future, strategies to use fossil fuels as cleanly as possible are needed as well.

Table 3-3 summarizes fossil fuel technologies being developed for utilities and industry that are inherently more efficient and of less impact to the environment than current technologies.

Natural gas is inherently cleaner than coal and is currently the most widely used combustion fuel in industry. Technology advances promise to further enhance the efficiency and thus the attractiveness of gas. The combined cycle concept (2a in Table 3-3) first combusts gas to drive a turbine, then uses turbine exhaust heat to drive a steam turbine—leading to higher overall efficiency. Some combustors (4a, 5a) use the gas turbine exhaust to generate steam but then route the steam and heat back into the same gas turbine rather than driving a separate steam turbine. This increases the gas turbine efficiency and lowers nitrous oxide emissions. World natural gas reserves, however, are estimated at less than 60 years at current production rates.[28] Thus, gas prices may rise in the years ahead.

Figure 3-3.—Total U.S. energy flow in quadrillion Btu, 1989.


Coal
net exports
2.58
Other
0.22
Hydropower
2.74
Nuclear power
5.68
Energy
production
65.71
Coal
21.23
Wet natural
gas
19.69
Crude oil and
lease condensate
16.15
Natural gas
net imports
1.31
Petroleum
net imports
15.15
15.95
2.85
14.68
Natural gas
plant liquids
2.16
1.68
Electric
net imports
0.11
Energy
consumed at
electric
utilities
29.20
2.70
0.03
3.12
Energy
consumed
directly in
end uses
52.04
Net imports
of coal coke
0.03
Conversion and
transmission
losses
20.22
5.85
10.59
19.37
0.01
22.11
Residential and
commercial 16.44
Industrial
22.44
Transportation
22.12
Total*
energy
consumed
81.23
Net energy
consumption
61.01
Residential
and
commercial
29.61
Industrial
29.47
Transportation
22.15

Source: U.S. Department of Energy, *Annual Energy Review 1989*, DOE/EIA-0384(89), (Washington, DC: Energy Information Administration, May 1990), page 5.

Table 3-3.—Comparison of costs, emissions, and efficiency of U.S. fossil fuel technologies.

TECHNOLOGY	PLANT COST	SO_2 REDUCED	NO_x EMITTED	ESTIMATED CARBON EMITTED	EFFICIENCY
	$*	%	*mg***	*kg****	%†
1. Conventional (steam turbine)					
a. Gas	760	—	180	.14	36
b. Coal scrubber	1600	90	300	.25	34
2. Combined cycle (steam and gas)					
a. Gas	520	—	15	.10	47
b. Coal gasification	1700	99	25	.20	42
3. Pressurized fluidized-bed combustion					
Coal combined cycle	1200	90	60	.19	42
4. Steam-injected gas tubrine					
a. Gas	410	—	15	.12	40
b. Coal gasification	1300	99	25	.24	36
5. Intercooled steam-injected gas turbine					
a. Gas	400	—	10	.10	47
b. Coal gasification	1030	99	20	.20	42
6. Advanced fuel cells					
a. Gas	600–800	—	5–20	.09–.10	50–55
b. Coal gasification	1000–1500	99	10–35	.17–.19	45–52

*dollars kilowatt of capacity.

**milligrams per million joules of electricity.

***kilograms of carbon as CO_2 kilowatt-hour.

†percent stored energy converted to electricity.

—trace emissions of SO_2.

Source: Adapted from Fulkerson, W., R.R. Judkins, and M.K. Sanghvi, "Energy from fossil fuels," *Scientific American* 263(3):133, (September 1990). Copyright © 1990 by Scientific American, Inc. All rights reserved.

A new breed of clean-coal technologies has been developed that is likely to become more competitive. These technologies achieve pollution reduction in the generation process rather than with scrubbers, allowing cleaner use of the world's large coal reserves. Table 3-3 presents the superior emissions and efficiency characteristics of the pressurized fluidized bed combustor and coal gasification systems (2b, 3, 4b, 5b, 6b). The fluidized bed technologies reduce pollutants during the combustion process. Coal mixed with limestone is combusted while suspended on jets of air (fluidized), and the sulfur is captured by the limestone. A drawback is that the limestone increases the solid waste volume as compared to a conventional coal plant.

Another alternative is to convert coal to gas, then remove the sulfur prior to combustion. The coal gas is combusted in a variety of ways that are conceptually the same as the natural gas systems just described. (The prototype gasification system that has been tested is the integrated gas combined cycle—IGCC. See 2b in Table 3-3.) An additional advantage of coal gasification is that solid waste is less than half

Texaco Syngas, Inc.

Coal gasification plants like this one in California's Mohave Desert promise increased energy efficiency with superior environmental performance compared to conventional coal plants.

that of a conventional coal plant. Coal gasification also has the potential for multiple uses. The gasifier can accept sewage or hazardous waste, fixing the hazardous elements into the inert glasslike slag that is a byproduct of the gasification process.[29] This material can then be used as a construction material in highways and other projects. In addition, the gas used to drive the turbine can also be a feedstock for industrial processes, such as for production of methanol, a transportation fuel. This presents the opportunity for an integrated industrial feedstock and energy production facility that uses resources abundant in the United States.[30]

The coal gasification and fluidized bed technologies have been tested in operation at various sites during the 1980s, and industries are considering them for planned new capacity.[31] The Tennessee Valley Authority, in cooperation with the Electric Power Research Institute, proposes to develop an IGCC process that will co-produce electricity and urea for fertilizer. The future leads to even higher efficiencies using the gas in combination with fuel cells (item 6 in Table 3-3). These concepts, still in research and thus likely to be unavailable until the 21st century, would eliminate combustion, deriving energy from an electrochemical process.

In summary, these systems demonstrate the advantages of avoiding pollution by design—at the front end of the process—and achieving better efficiency. The advantage also extends to global markets. The United States enjoys a competitive lead in these technologies and is likely to remain a leader.[32] Other countries with large reserves of coal, such as China and the U.S.S.R., are prime candidates to adopt U.S. clean coal technology.

Energy Efficiency

Pollution prevention and energy efficiency are closely related not only in the powerplant but also in end uses of energy.

From 1970 to 1989 U.S. electricity use grew 89 percent, and gross national product (GNP) in constant dollars grew 71 percent, while basic energy consumption in the United States rose only 22 percent—clear evidence of an increasingly energy-efficient economy.[33] Overall, the United States is becoming more efficient as it phases in new technology and switches to electricity from direct fuel use at the end-use level. These trends are likely to continue: concern over uncertain fuel prices will drive efficient technologies, while growing electricity use is a product of its inherent flexibility, economy, and stability.

Energy efficiency gains have been the target of many recent studies. Trends in end uses are linked to economics and consumer preferences, which government policy may influence but cannot control. The results of such studies vary widely depending upon the assumptions used. Nonetheless, most studies agree that overall end-use demand will increase in the future. Efficiency gains will restrain demand growth but probably will not reduce demand below current levels.[34]

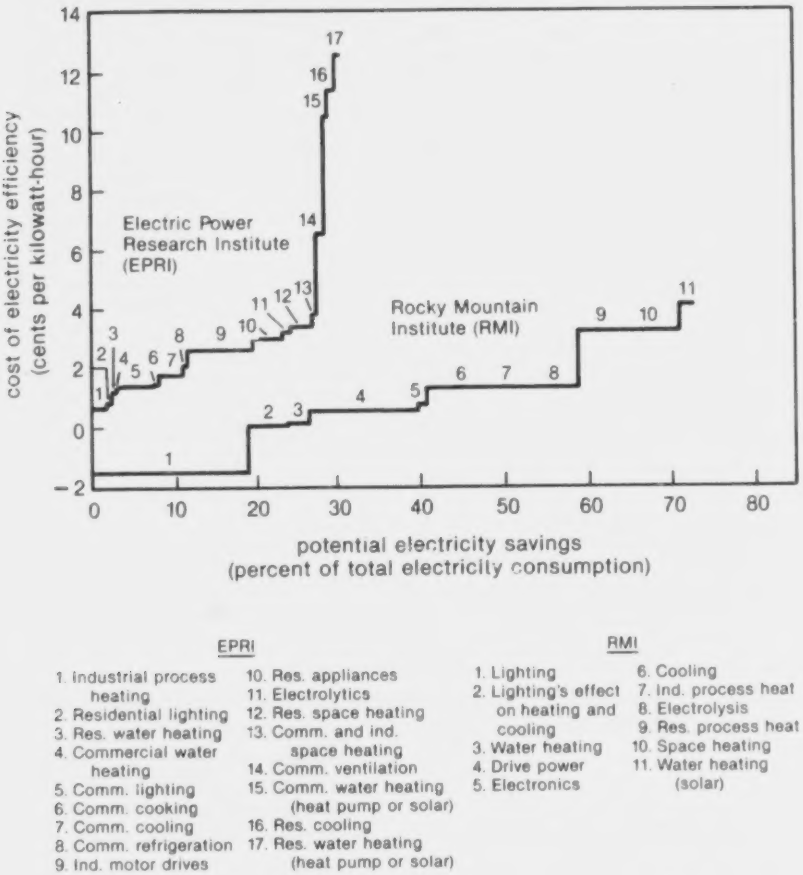
A useful way to examine efficiency potential is through its relationship to cost. Figure 3-4 demonstrates how differing assumptions can lead to different predictions of potential electricity savings for various costs. The two estimates from the Electric Power Research Institute and the Rocky Mountain Institute generally agree on those technologies that have greatest potential for cost-effective savings (lighting and motors) but disagree on the costs involved.

Building Sector

Using models from Department of Energy national laboratories, Table 3-4 divides national energy consumption into a building sector, industrial sector, and transportation sector.

The building sector's consumption is 37 percent of total U.S. energy consumption. By far the largest demand is for space heat, air conditioning, and ventilation in both the residential and commercial components of the building sector. Next, a large "other" category covers numerous appliances, followed by commercial lighting, residential water heat, and refrigerators. These are the logical targets for demand reduction.[35]

Figure 3-4.—Estimated cost and scale of potential electricity savings, 1990.



Source: Adapted from Fickett, A.P., C.W. Gellings, and A.B. Lovins, "Efficient use of electricity," *Scientific American* 263(3):72, (September 1990). Copyright 1990 by Scientific American, Inc. All rights reserved.

Prospects for major building savings are shown in Tables 3-5 and 3-6. Other significant improvements could include the following:[36]

- **Better Building Shells.** Homeowners are familiar with the notion of improvements in space heat and cooling if they have considered window coatings and better home insulation. For example, single-glass R-1 windows have poor insulating capability. R-2 double-glazed windows (two panes separated by a

Table 3-4.—U.S. fuel consumption by sector in 1985, 1988, and 1990.

SECTOR	1985	1988	1990
	quadrillion Btu		
Industrial	27.1	29.1	29.1
Transportion	20.1	21.9	21.7
Building	26.8	29.1	30.3
Residential			
Space heat	6.5		7.0
Water heat	2.8		2.9
Refrigerator	1.9		2.0
Air conditioning	1.1		1.2
Other	3.7		4.1
Total	16.0		17.2
Commercial			
Space heat			4.1
Air conditioning			1.3
Ventilation			1.6
Lighting			3.3
Other			2.8
Total	10.8		13.1
By fuel			
Electricity	16.9	18.7	19.3
Oil	2.6	2.7	2.1
Natural gas	7.1	7.5	8.4
Coal/other	0.2	0.2	0.5
Total	26.8	29.1	30.3

Source: Data is adapted from the Lawrence Berkeley Laboratory Residential Energy Model and the National Commercial Energy Model maintained by Pacific Northwest Laboratories as reported in Carlsmith, R.S., et al., *Energy Efficiency: How Far Can We Go?* ORNL/TM-11441, (Oak Ridge, TN: Oak Ridge National Laboratory, January 1990).

Table 3-5.—Savings potential and cost effectiveness of energy-efficient lighting technologies.

TECHNOLOGY	SAVINGS POTENTIAL*	ENERGY PRODUCED	UNIT COST**	SIMPLE PAYBACK
	%	*kWh/yr*	*1988$*	*year*
Compact fluorescent replacing incandescent	60–75	125–200	15–20	1.1–2.3
High-efficiency fluorescent lamp***	15–20	23–31	1–2	0.5–1.2
High-efficiency magnetic ballast†	10	30–40	4–6	1.4–2.8
Electronic ballast††	20–25	70–90	25–40	3.9–8.0
Optical reflector†††	30–50	150–300	25–50	1.2–4.7
Day-lighting controls	25–50	2.2–4.4	0.5–1.5	1.6–9.6
Occupancy sensors	30–50	2.6–4.4	0.4–1.0	1.3–5.4

*Lighting electricity savings, assuming lights in a commercial building are 3,500 hr/yr.

**Cost includes installation for add-on retrofit measures. In cases where an efficiency product replaces a standard product, the incremental equipment cost is given.

***Based on the 1986 national-average commercial-sector electricity price $0.071/kWh. Based on a 48" fluorescent tube, the most common type.

†Based on a ballast that operates two 48" fluorescent lamps, the most common cir design.

††Based on removal of one or two 48" lamps from a fixture originally containing three or four lamps.

†††The electricity-savings potential and unit-cost values are provided per sq. ft. floor area, assuming installation in a large office building.

Source: Geller, H.S., "Commercial Building Equipment Efficiency: A State-of-the-Art Review," (Washington, DC: American Council for an Energy Efficient Economy, May 1988), Table 25-92 in National Acid Precipitation Assessment Program, *State of Science/Technology Report 25*, (Washington, DC: NAPAP, in press).

Table 3-6.—Energy consumption and conservation potential of major residential appliances, 1986–1990.

PRODUCT	1986 STOCK*	1986 NEW**	1986 BEST***	ADVANCED TECHNOLOGY FOR 1990s†
	unit energy consumption (UEC)			
Refrigerator	1450	1100	750	300–500
Freezer	1050	750	430	200–300
Central air conditioning	3500	2900	1800	1200–1500
Room air conditioning	900	750	500	300–400
Electric water heating	4000	3500	1600	1000–1500
Electric range	800	750	700	400–500
Electric clothes dryer	1000	900	800	250–500
Lighting	1000	1000	650††	350–500
Gas space heating	730	620	500	300–500
Gas water heating	270	250	200	100–150
Gas range	70	50	40	25–30
Gas clothes dryer	50	40	35	30–35

*UEC per typical installation in the 1986 housing stock.

**UEC for the typical model produced in 1986.

***UEC for the best model mass-produced in 1986.

†UEC possible in new models by the mid 1990s, if further cost-effective advances in energy efficiency are made.

††Assume that most-heavily used incandescent lamps are replaced with compact fluorescent.

Source: Geller in NAPAP, Table 25-94.

quarter-inch of air) are twice as resistant to heat loss. Better insulating windows with ratings as high as R-19 have been created by adding coatings and layers of gas between the panes. "Super" windows cost more than conventional windows but cut monthly energy bills. As insulation is improved, owners may need to provide adequate ventilation to avoid indoor air pollution.

- **Advanced Equipment.** Better controls or new uses for appliances have potential. Sensors can switch lighting or appliances off after a given period of disuse. Hot water heaters may double as furnaces in a super insulated house.

- **Tree Planting.** By planting shade trees and painting structures lighter colors, owners can save 20 to 50 percent of a building's cooling wattage on a hot day.

Industrial Sector

Government statistics collected on U.S. industrial energy use present the big picture of economic activity and opportunities for energy efficiency. Table 3-4 shows that in 1990 the industrial sector consumed approximately 36 percent of the total gross U.S. consumption (including transmission and conversion losses by utilities). Table 3-7 breaks out energy consumption by the manufacturing sector in 1985, the last year

Table 3-7.—Energy consumption by the manufacturing sector by industry group and type of fuel, 1985.

SIC CODE	INDUSTRY	TOTAL CONSUMPTION	NET ELECTRICITY*	FUEL OIL**	NATURAL GAS	COAL AND COKE	OTHER
		trillion Btu					
	Total	13,747.9	2,286.5	705.2	4,617.7	1,980.3	4,158.2
20	Food and kindred	954.3	165.8	65.1	458.9	131.7	132.9
21	Tobacco products	19.8	4.6	2.3	3.4	9.4	.1
22	Textile mill products	248.1	88.1	21.3	91.2	38.0	9.7
23	Apparel and other textile products	32.4	15.3	2.9	12.5	1.4	.4
24	Lumber and wood products	348.9	55.1	23.4	31.4	(D)	(D)
25	Furniture and fixtures	48.6	15.2	2.7	19.6	2.1	9.1
26	Paper and allied products	2,355.6	183.6	166.9	379.7	322.5	1,302.9
27	Printing and publishing	98.6	52.5	2.4	40.6	(D)	(D)
28	Chemicals and allied products	2,460.5	445.2	100.3	1,180.9	336.4	397.7
29	Petroleum and coal products	2,426.3	120.3	134.9	690.7	7.3	1,472.9
30	Rubber and misc. plastic products	220.8	90.7	15.2	102.0	8.1	4.8
31	Leather and leather products	13.4	4.3	3.3	4.5	.9	.4
32	Stone, clay, and glass products	927.6	116.3	33.1	397.0	349.0	32.3
33	Primary metal industries	2,362.2	458.7	53.2	669.2	660.6	520.5
34	Fabricated metal products	296.2	91.2	16.7	171.6	8.7	8.0
35	Machinery, except electrical	277.6	114.2	14.6	113.7	30.6	4.5
36	Electrical and electronic equipment	223.7	110.1	10.4	91.4	8.6	3.3
37	Transportation equipment	322.2	115.0	25.7	120.7	43.8	17.0
38	Instruments and related products	79.7	29.2	8.1	23.6	(D)	(D)
39	Miscellaneous manufacturing	31.3	11.4	2.6	15.4	1.3	.7

Note: Data is based on a Manufacturing Energy Consumption Survey and subject to sampling variability.

D = Figure withheld to avoid disclosure.

*Net electricity is obtained by aggregating purchases, transfers in, and generating from noncombustible renewable resources minus quantities sold and transferred out.

**Includes distillate and residual.

Source: U.S. Energy Information Administration, Monthly Energy Review, (January 1987) in Department of Commerce, U.S. Bureau of the Census, *Statistical Abstracts of the United States 1988*, (Washington, DC: U.S. Government Printing Office, 1987), page 542.

for which data were available, excluding electrical losses, energy used as feedstock (such as natural gas and petroleum), and several industrial sectors: construction, mining, agriculture, fishing, and forestry.

These statistics indicate that the largest industrial consumers of energy were, in descending order: chemicals, petroleum and coal, primary metals, and paper, each of which consumed more than 2.0 quads. The next cluster of energy users were food and kindred products and stone-clay-glass, using just under 1.0 quad each. All other listed industries consume much smaller amounts of energy.

Energy efficiency by the manufacturing sector is addressed in Table 3-8.

Table 3-8.—Energy efficiency of the manufacturing sector by industry group, 1980 and 1985.

SIC CODE	INDUSTRY GROUP	ENERGY EFFICIENCY RATIOS* 1980	ENERGY EFFICIENCY RATIOS* 1985	ENERGY EFFICIENCY CHANGE**
		thousand Btu/$		%
20	Food and kindred products	3.5	2.7	22.9
21	Tobacco manufactures	W	W	W
22	Textile mill products	5.7	4.8	16.3
23	Apparel and other textile products	NA	NA	NA
24	Lumber and wood products	W	W	W
25	Furniture and fixtures	1.9	1.6	17.4
26	Paper and allied products	16.0	13.9	13.0
27	Printing and publishing	1.1	0.9	15.2
28	Chemicals and allied products	15.1	12.4	17.6
29	Petroleum and coal products	5.4	4.4	19.8
30	Rubber and misc. plastics products	4.3	3.1	27.8
31	Leather and leather products	W	W	W
32	Stone, clay, and glass products	21.6	16.6	23.0
33	Primary metal industries	16.4	14.6	11.0
34	Fabricated metal products	2.8	2.3	16.4
35	Machinery, except electrical	1.7	0.9	43.6
36	Electrical and electronic equipment	1.7	1.2	26.4
37	Transportation equipment	1.5	1.1	25.0
38	Instruments and related products	1.7	1.2	29.3
39	Misc. manufacturing industries	1.8	1.4	23.9
—	All manufacturing	5.8	4.4	25.1

*Thousand Btu per constant (1980) dollar of value of shipments and receipts.

**A decrease in the energy efficiency ratio results in an increase in energy efficiency represented by a positive value.

W = Withheld because relative standard error is greater than or equal to 50 percent.

NA = Not available.

Source: DOE, *Annual Energy Review*, page 39.

These figures show varying levels of efficiency, calculated as the ratio of energy use per dollar of value of shipments and receipts. The most energy-intensive industries are stone-clay-glass, primary metals, paper, and chemicals, with ratios in the range of 12-1 to 16-1—well above those of other industries. This variation is explained by the fact that the most energy-intensive activities are those that convert raw materials into usable form for other industries. A comparison of Tables 3-7 and 3-8 reveals that these basic processing industries are among the top users of petroleum and coal and thus they contribute heavily to energy-related pollution. To the extent that industrial energy efficiency can be improved—gaining greater output from the same or less energy input—economic and environmental objectives may be achieved simultaneously.

The data in Table 3-8 on changes in efficiency show a substantial improvement since 1980 in most manufacturing sectors, ranging from 11 percent for primary metals to nearly 44 percent for machinery. Even so, efficiencies remain far below the theoretical maximums imposed by the laws of thermodynamics. For example, one study estimated that the iron and steel industry is at approximately 23 percent of maximum achievable efficiency, aluminum at 13 percent, and petroleum at 9 percent. The pulp and paper industry, which could theoretically use its own lignin wastes for fuel, currently uses as much as three-quarters of a ton of oil to produce one ton of paper.[37]

Despite the diversity of industrial activities in the United States, generic technologies are in development, both near- and long-term, that have the potential to improve efficiency and prevent the pollution contribution of many industries. Among these cross-cutting developments are the following:[38]

- **High Efficiency Motors.** Motors represent more than half of the nation's industrial uses of electricity. High efficiency models have variable speed drives that adjust up or down with load and may someday use high temperature superconducting materials.

- **New Catalysts.** New classes of catalysts are an appropriate target for research to promote lower energy chemical conversions, as in the production of methanol from methane or in certain emission control devices.

- **Separation Processes.** Less energy-intensive separation processes are needed with better membrane materials, better solvent extraction techniques, and advanced heat recovery and use in paper and textile processing.

- **Heat Recovery and Cogeneration.** Using in-house waste heat to drive turbines for energy cuts utility bills. Typical cogeneration in industry turns 10 to 15 percent of energy to electricity; steam-injected turbines can exceed 40 percent.

In the chemical, petroleum, and stone-clay-glass industries, generic technology improvements offer the greatest promise for pollution prevention. Primary metals manufacturing could benefit from several industry-specific efficiency improvements.[39] The amount of energy needed to produce steel in 2010 could be cut 42 percent, an improvement of 2.4 percent per year, through greater use of such technologies as the currently available electric arc furnace, which is more efficient than combustion furnaces and can use virtually 100-percent scrap; near net-shape casting, currently available and well understood; and direct steelmaking, still in development, which combines four smelting processes into one step. A 1.5-percent-per-year improvement through 2010 would merely bring U.S. steelmakers to the 1990 Japanese level of efficiency.

For other metals, the efficiency of aluminum production could be enhanced up to 36 percent by 2010 with improved electrolytic reduction cells and electrodes and related advances in research or development. An efficient technique for nonferrous smelting is available—flash smelting—that also attacks the largest single source of industrial process sulfur emissions. By increasing the concentration of sulfur dioxide in the smelter emissions, removal of sulfur dioxide by acid plants is improved to 96 to 99 percent.[40] Greater use is a financial decision, however.

In the paper industry, 33- to 40-percent improvements in energy efficiency may be possible by 2010 by using such advances as continuous digesters, oxygen bleaching, better evaporators, computer controls, sensors, and better drying techniques. Paper recycling uses only half the energy of the prevalent Kraft production process.[41]

Indeed, greater recycling can reduce not only the nation's quantity of solid waste but also the pollution associated with energy use. The most energy- and pollution-intensive operations involve the preparation of virgin materials. Ironically, many companies look for ways to reuse the scrap they create in the factory, but few retrieve their products after they are used by the consumer. Among those industries in which recycling occurs, some experts have estimated that recycled glass requires only 70 percent of the energy needed for new glass, recycled steel approximately 65 percent, plastic 37 percent, and aluminum—recycling's greatest success story—28 percent.[42]

Encouraging Energy Efficiency

The pollution prevention ethic, which tends to merge economic and environmental objectives, obviously requires that energy services be provided in the cleanest, most efficient manner possible. How can the nation advance energy efficiency?

A basic reliance on market forces can be expected to provide an incentive for both short-term efficiency improvements and long-term technological change. This was demonstrated in the economy since 1973 as overall energy efficiency improved in response to energy supply disruptions, price volatility, and the introduction of new technologies. The efficiency progress slowed when energy prices eased.

Utility Programs

Market forces have had a slower and more limited impact on electric utilities since their prices and practices are regulated by state public utility commissions (PUCs). Traditionally, even though utilities in some states were reimbursed for the costs of efficiency measures and environmental controls, the incentives were inadequate to offset the depressed revenues resulting from such programs. Regulatory policies tended to meet growing demand by simply using economic cost comparisons to select the next plant addition.

Recently, coalitions of utilities, environmental groups, and small energy service companies have collaborated with state PUCs to develop profit incentives to enable utilities to earn a return on efficiency investments commensurate with that earned on supply-side investments. Profit incentives are being implemented in Rhode Island, Massachusetts, New York, and California, and related regulatory reforms are proceeding in other states under various labels: demand-side management (DSM), least-cost utility planning (LCUP), integrated value-based planning (IVP), or integrated resource planning (IRP). Currently, 29 states are examining steps to incorporate environmental costs into electric resource decisions. What these reforms all have in common is an attempt to develop mechanisms that allow companies and regulators to evaluate both supply- and demand-side options on a level playing field. In almost every case, energy efficiency investments are being transformed from an afterthought to a profitable priority.[43]

Today, industry leaders such as Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and New England Electric System (NEES) are moving vigorously ahead. PG&E expects to meet three-quarters of its new demand through the year 2000 with efficiency and conservation savings, spending up to $2 billion on the effort.[44] SCE conducts its "Welcome Home" program to foster the building of houses, condominiums, and apartment buildings that are energy-efficient. The program also provides homebuyers with energy audits, advice, rebates on the purchase of efficient equipment, and devices to manage energy wisely. The utility set a goal for 1990 of seeing 20,000 new residential units built to program standards.[45] NEES has joined forces with the Conservation Law Foundation to provide $85 million in 1991 to customers for efficient lighting, insulation, and weatherization in 20,000 homes. The utility, which also purchases and installs efficient motors, lighting, heating, and ventilation in the commercial sector, plans total efficiency investments of $420 million over the next six years.[46]

The 1990 amendments to the U.S. Clean Air Act will also promote the campaign for efficiency. Under the acid rain portion of the new law, utilities have the flexibility and the incentive to make the largest reductions possible, at least cost. And in nearly every case, efficiency investments will be a part of the equation. A study sponsored in part by a bipartisan coalition of state governors showed that utilities hardest hit by the acid rain portions of the Clean Air Act could cut their compliance bill in half through aggressive efficiency and conservation programs.[47] Electricity demand restraint will also help to buy time for improvements in the technology of energy production and emissions control.

Federal leadership can also stimulate the market in "negawatts"—energy savings—by encouraging more efficient housing, buildings, and equipment. To achieve energy savings in commercial structures, the Department of Energy (DOE) has developed a set of voluntary standards that will be revised approximately every five years to stimulate innovation and reflect the current state of technology. Application of these standards in new commercial construction is expected to result in energy savings of 20 to 25 percent. As for equipment, DOE will soon issue mandatory updated national energy standards for new washing machines, dryers, and dishwashers. Such mandatory standards were issued for refrigerators in 1989. DOE has also begun efforts to update the mandatory efficiency standards for furnaces, air conditioners, heat pumps, and other major residential appliances.

Government can also be a catalyst for change by altering its energy consumption habits. DOE building standards are mandatory for new federal buildings. Contracts for retrofits of existing buildings to make them more energy efficient are on the rise as local utilities see inefficient federal buildings as targets of opportunity. In one such program, the General Services Administration, in coordination with the Potomac Electric Power Company, will install lighting retrofits in about 25 of the largest federal buildings in the Washington, DC, area. By 1992, the project is expected to save 25 percent of the energy used for lighting these buildings. Overall, the federal government could save up to 10 percent of its building energy use per square foot by 1995 and 20 percent by 2005, compared to 1985 levels.[48]

Barriers to Energy Efficiency

Barriers do exist in the path of energy efficiency progress. The invigorated efficiency movement will require time and effort to permeate the national scene. As with pollution prevention, a primary challenge is information: only a modest amount is available concerning the costs and performance of energy demand-management programs. A concerted effort by DOE, the industry-sponsored Electric Power Research Institute (EPRI), and other organizations to gather more data from actual experience will enable interested parties to design more successful programs. Currently, DOE provides assistance to utilities and state public utility commissions through its Integrated Resource Management Program (IRP), which helps measure the effectiveness of efficiency programs and operates a national data bank. Funding for this program totaled $1.3 million in fiscal 1990 and $3 million in fiscal 1991.

Energy-efficient systems that are cost-effective over their life-cycle generally have higher first costs. Builders tend to be interested in first costs and have not been accountable to owners for energy efficiency. Only a handful of mortgage lenders encourage buyers to finance efficiency improvements at the time of purchase. Owners who rent their dwellings to others frequently do not pay the utility bills, so price signals may not lead to efficiency improvements.

Industry managers often require paybacks of two years or less for cost-saving investments such as energy efficiency. Other choices being equal, industry also tends to allocate greater capital funds to market share development rather than cost-saving efficiency investments.[49] A long-term capital investment program favoring efficiency will therefore require changes in attitudes as much as correct information and price signals.

The source of long-term change in end-use efficiency is research, development, and commercialization of technologies that address both energy and environmental needs. Federal funding for energy efficiency research and development is likely to remain a fraction of that for energy production. Ultimately, therefore, efficiency progress depends on market signals and the initiative of the private sector. But the short capital-recovery requirements by businesses today do not favor long-term energy investment, particularly in small- and medium-sized companies.[50] Public-private partnerships, such as those authorized by the National Competitiveness Technology Transfer Act of 1989, which directed the national laboratories to help speed the transition of new technologies into the marketplace, can expand the capital-recovery horizon. Not only should this research and development be focused on better demand-side items such as efficient appliances, windows, or building designs, but also on cleaner and more productive supply options.

Existing Programs

The nation is making considerable efforts to meet the technical challenge of pollution prevention at the federal, state, and local levels. Legislation and government programs can be catalysts for wider adoption of the pollution prevention ethic. But government action by itself, no matter how clear or prescriptive, is insufficient. Other methods such as market incentives and education are also necessary. This section provides snapshots of the key activities and progress in 1990.

Federal Agencies

Several federal departments and agencies with antipollution responsibilities moved forward toward pollution prevention in 1990. Among others, EPA advanced an array of programs, and both CEQ and EPA developed outreach and policy initiatives. The Department of Agriculture continued to pursue pollution prevention initiatives oriented toward the large nonpoint source issues of the nation's croplands, and the Department of Transportation gained new responsibilities under the Oil Pollution Act of 1990 and the new National Transportation Policy.

As a major building landlord, the General Services Administration (GSA) actively pursued an energy conservation program that reduced energy consumption 25 percent from 1973 to 1975 and an additional 25 percent from 1975 to 1985, while reducing petroleum consumption 76 percent during the same period. GSA also administered an underground storage tank testing and remediation program and a hazardous materials spill prevention and control program. Along with an emphasis on recycling in its office buildings, GSA is giving priority to building insulation that uses recovered materials.

The Department of Energy (DOE) and the Department of Defense (DOD) incorporated prevention into their large industrial operations and hazardous waste programs. These two departments have worked closely with EPA as the requirements for waste management have progressed toward the pollution prevention doctrine. The DOE and DOD programs will contribute to the national environmental effort beyond their operations; they also represent test beds for technologies of use to the private sector and markets for materials that could be provided from processes using pollution prevention.

Environmental Protection Agency

As the nation's primary environmental regulatory agency, EPA has named pollution prevention one of its priorities for the 1990s and beyond. In its report of September 1990, the EPA Science Advisory Board recommended an emphasis on pollution prevention as the preferred option for reducing risk.[51]

In 1988, EPA established an Office of Pollution Prevention within its Office of Policy, Planning, and Evaluation, and in each of its ten regional offices. More recently, EPA released a pollution prevention strategy for the following purposes:

- Addressing obstacles,
- Expanding public participation,
- Emphasizing partnerships with the private sector and with other federal agencies,
- Supporting state technical assistance programs,
- Promoting outreach and training,
- Integrating pollution prevention concepts in regulations and permits,
- Leveraging enforcement,
- Underscoring a research strategy,
- Encouraging cleaner products and technologies, and
- Promoting institutional change within EPA.

The EPA strategy addresses pollution prevention in terms of manufacturing and chemical use, agriculture, and energy (including transportation).[52] It also reiterates the EPA plan to target certain chemicals for voluntary reductions. The agency is identifying 15 to 20 toxics of greatest concern from the Toxics Release Inventory and proposes a goal of reducing the total releases of these target chemicals by one-third by 1992 and by at least half by 1995.

Commitments of staff, grants, and contract dollars have helped introduce the pollution prevention ethic to EPA employees and citizens. The agency has committed nearly $11 million since 1989 to incentive grants for source reduction, recycling, and pollution prevention. These grants have strengthened state technical assistance programs for industry. In 1991 and 1992 EPA offices plan to set aside 2 percent of contract dollars (approximately $12 million) for innovative pollution prevention projects. The projects will address issues ranging from education to methods for low-input sustainable agriculture (LISA).

EPA also conducts outreach efforts to share innovative technologies and practices with numerous industries. The agency maintains a Pollution Prevention Information Clearinghouse, which is accessible to the public by means of a telephone hotline or by a personal computer. The clearinghouse provides, among other things, a calendar of events; state, federal, and corporate program summaries; and case study abstracts. The Pollution Prevention Office publishes a monthly newsletter, *Pollution Prevention News*, and produced an award-winning videotape through a public-private initiative.

In 1989 EPA and the University of Cincinnati established the American Institute for Pollution Prevention, comprised of volunteer experts who work in councils to advance pollution prevention technologies and who provide a cooperative liaison channel between EPA and industry. Councils on economics, education, implementation, and technology sponsor such projects as a practical guide to pollution prevention economics, pollution prevention design problems for engineering courses, and analysis of regulatory and legislative barriers to pollution prevention.[53]

EPA devotes a portion of its research and development to pollution prevention. The agency has a cooperative extramural program, jointly executed with outside agencies, industry, and public groups, and an intramural program within EPA. Currently, EPA funds 68 projects under the following headings:[54]

- **Pollution Prevention Research Branch.** This unit is located at the EPA Risk Reduction Engineering Laboratory in Cincinnati, Ohio. The laboratory's Waste Minimization Branch conducts projects totaling approximately $3.5 million, including the Waste Reduction Innovative Technology Evaluation (WRITE), Waste Reduction Assessments Program (WRAP), Waste Reduction Evaluations at Federal Sites (WREAFS), and the Waste Reduction Institute for Senior Executives (WRISE).[55]

- **Two-Percent Set-Aside Program.** Each year, EPA offices set aside 2 percent of contract dollars for innovative pollution prevention projects. Many of these are research and development projects.

EPA's pollution prevention research projects fall into six categories:[56]

- **Products.** The products program focuses on preventing pollution throughout the life cycle of a product, especially during its use and disposal. Typical projects include a cooperative venture with the University of Tennessee identifying safe product substitutes, a clean products case studies project by INFORM (a private organization), and an industry product design manual being produced by the University of Michigan.

- **Process.** WRITE projects in California, Connecticut, Illinois, Minnesota, New Jersey, Washington, and New York focus on evaluating innovative process technologies and techniques that prevent pollution. These cooperative projects range from 18 industry-specific assessment manuals produced in cooperation with the California Department of Health Services to 30 assessments of small- and medium-sized businesses in New Jersey using university teams. The EPA Cincinnati laboratory developed the *Waste Minimization Opportunity Assessment Manual*, used widely for environmental audits and for determining technology needs.

- **Recycling and Reuse.** Among the current recycling projects is newsprint reclamation using a dry fiberizing process.

- **Socioeconomic and Institutional Demonstrations.** Research includes community demonstrations by Tufts University, the University of Pittsburgh, the City of Milwaukee, and a cooperative model communities project with the Department of Defense.

- **Anticipatory Research.** EPA-sponsored university research centers and hazardous substance research centers analyze emerging trends and changing needs.

- **Technical Transfer and Outreach.** Mechanisms include the Pollution Prevention Information Clearinghouse, the American Institute for Pollution Prevention, the National Advisory Committee for Environmental Policy and Technology, the EPA Science Advisory Board, and numerous publications, workshops, and conferences.

In summary, EPA leverages its pollution prevention resources to achieve maximum results by cooperating with others. With growing antipollution responsibilities on its agenda—including implementation of the 1990 Clean Air Act Amendments and upcoming reauthorization of the Clean Water Act and Resource Conservation and Recovery Act (RCRA)—EPA is poised to integrate prevention into all its activities and into those of the nation at large.

The Department of Defense

The success of the pollution prevention ethic depends in no small part upon commitment by leaders and managers of large organizations. Among the nation's largest organizations, the Department of Defense (DOD) made a public commitment in late 1989 to be the leader in federal agency environmental compliance and protection.[57] Integrating the environmental ethic into all facets of DOD will rely on intensive cooperation with the private sector and on the attitudes and dedication of the nearly four million DOD employees worldwide.[58]

Pollution prevention at the Department of Defense has made significant progress since 1985, when it began to evolve as a priority. In that year, EPA issued regulations to implement the Hazardous and Solid Waste Amendments Act (HSWA) of 1984. Seed money for hazardous waste minimization (HAZMIN) within DOD was allocated to be managed within the Defense Environmental Restoration Program

(DERP), DOD's equivalent to the civilian Superfund program. In 1987 under the HAZMIN program, each service—Army, Navy, and Air Force—established goals to cut waste in half by 1992, although the definition of minimization for this prototype program included such nonpreventive techniques as delisting and treatment.[59]

In 1989 a new directive on Hazardous Material Pollution Prevention provided the focal point for hazardous material management and genuine waste minimization efforts. The new directive requires DOD components and the military services to develop comprehensive guidance and programs to prevent pollution. It emphasizes information exchange and cooperation with other agencies, allied nations, and outside groups.[60]

Also in September 1989 DOD established an intra-agency Hazardous Material Pollution Prevention Committee (HMPP) to monitor and evaluate pollution prevention activities. The committee coordinates the development of a long-term strategy, fosters effective exchange efforts, and serves as a forum to provide DOD guidance on pollution prevention. DOD instituted an effort within the Defense Logistics Agency to reuse hazardous materials to prevent them from becoming hazardous waste.[61]

Current research and development under the HAZMIN program parallel that of private industry, although with a few defense-specific techniques such as recycling off-grade TNT during production. Priorities similar to those of industry include eliminating, reclaiming, or substituting alternatives for cleaning solvents; using plastic pellets rather than solvents to strip paint; and using alternatives to chlorofluorocarbons for electronic and metal cleaning.[62] Because DOD is a large user of CFCs and halons, which damage the Earth's protective ozone layer, a Departmental CFC Advisory Committee is conducting a study on ways to phase out CFCs and halons from procured equipment and supplies.[63]

In 1990 an effort called the Defense and the Environment Initiative (D&EI) was launched to increase day-to-day environmental sensitivity and prepare environmental strategies. It envisions a long-term, problem-solving effort, employing partnerships in environmental matters. A September 1990 D&EI conference brought together several hundred defense and civilian leaders to review the near- and long-term DOD environmental strategy, including opportunities for pollution prevention; ways that global strategic policy might encompass environmental issues; and development of an enhanced DOD environmental decisionmaking structure.[64]

Examples of DOD's pollution prevention program can be found at various facilities:

- **Philadelphia Naval Shipyard.** An assessment of the shipyard found potential cost savings of $158,000 by controlling waste paint and making changes in cleaning and rinsing aluminum products.[65]

- **Fort Riley, Kansas.** Assessment of the maintenance of trucks, tanks, and armored personnel carriers at the site's motor pools identified recycling options for battery acid and parts cleansers for an anticipated net savings of $149,400 per year at Fort Riley, with potential for savings at ten similar posts.[66]

- **Tinker Air Force Base.** Solvent testing has shown that waste disposal of halogenated and petroleum-based solvents can be reduced significantly, potentially saving the Air Force $4 million yearly in waste disposal costs.[67]

In another initiative, DOD and EPA have agreed to a joint demonstration of the model community concept.[68] At three facilities in the Chesapeake Bay area—Langley Air Force Base, Norfolk Naval Base, and Fort Eustis—three different services will incorporate pollution prevention into all installation activities. The program, designed to demonstrate multimedia pollution prevention and energy conservation with applicability to other communities, is based on the total quality management principle, involving all members of the community. In military terms, DOD's efforts are "a coordinated land-air-water assault on pollution."[69]

Department of Energy

In the past two years, the Department of Energy (DOE) has made a strong commitment to environmental progress. Organizational changes consolidated environmental responsibilities into an Office of Environmental Restoration and Waste Management, and "tiger teams" reviewed environmental procedures in the field.[70] Part of this new emphasis includes pollution prevention, of obvious value to a department whose estimated cleanup bill is $30 billion for fiscal 1991 through 1996. In 1990 DOE issued a waste reduction policy statement that will lead to comprehensive pollution prevention efforts. It establishes a single program to assure that each DOE operating facility organizes a comprehensive waste-minimization program to include goals and schedules, tracking of waste streams, waste minimization methods and technologies, employee training and awareness programs, and compliance with all federal and state regulations.[71]

DOE's pollution prevention program builds on waste minimization efforts launched in 1989. At that time, DOE published a plan to clean up its nuclear-related waste sites and generally bring its aging facilities into compliance with current environmental laws and regulations. That plan identified the need to develop new technologies for problems currently lacking solutions. Subsequently, a draft Research, Development, Demonstration, Testing, and Evaluation (RDDT&E) Plan was also published in 1989.[72]

These plans were incorporated into an ambitious five-year plan through fiscal 1996 for Environmental Restoration and Waste Management. The plan explicitly recognizes the need for cultural as well as technical changes throughout the DOE complex, including a "design for minimization" philosophy. The goal is to reduce manufacturing waste generation by 50 to 80 percent within ten years of program initiation. Significant waste reductions throughout the DOE system could save $10 billion in waste treatment, storage, and disposal costs over the next 20 years.[73]

Because radioactive materials present special problems, the nation devotes considerable funds to technology development and remediation at DOE sites. Synergism between remediation teams and pollution prevention engineers could advance the state of the art, using DOE sites as large laboratories for radioactive pollution prevention as well as the hierarchy of protection options.

Site remediation and restoration, especially of radioactive and hazardous waste sites, have been priority projects in recent years, but DOE recognizes the generic advantages of a pollution prevention strategy. Refinements to processes at DOE sites are occurring in much the same way as in industry. Technology development in 1990 saw work in alternative cleaning processes, material substitution, process improvements, and recycling. Production sites conducted assessments for the next iteration of the comprehensive waste minimization plan.[74]

The following case studies are typical of progress at DOE research, development, and production plants:

- **Rocky Flats.** This Colorado site, which produces components for nuclear weapons, established a waste minimization program in January 1988. The focus is on eliminating three hazardous solvents (TCA, carbon tetrachloride, and chlorofluorocarbons) used for cleaning in maintenance and manufacturing throughout the plant. The program has achieved an 80-percent reduction in the use of TCA and CFCs in nonplutonium manufacturing. Through more careful use of solvents in cleaning operations, employees in plutonium manufacturing reduced the use of carbon tetrachloride from 14,000 gallons in 1988 to 10,500 gallons in 1989.[75]

- **Los Alamos National Laboratory.** At this New Mexico facility, a program for recycling and reusing hazardous chemicals has resulted in a number of changes. The laboratory installed an electrolytic silver-recovery system to eliminate disposal of silver-bearing wastes and to provide a financial return to the laboratory. Other techniques replace or recover halogenated solvents, recycle machine coolants, pull mercury out of the waste stream and recycle it, screen lead for reuse, recycle used oil, recycle 75 percent of office paper, and reduce the use of organic solvents through substitution. Every pound of material recycled saves up to $50 plus the cost of replacement materials.[76]

- **Sandia National Laboratory.** This New Mexico laboratory conducts a program to reduce and possibly eliminate hazardous liquid wastes resulting from the use of CFCs and chlorinated hydrocarbons in manufacturing cleaning processes. The Sandia project is carried out in conjunction with three other DOE production facilities, involves hundreds of components, and could have wide applications throughout DOE facilities. Projects to replace chlorinated solvents will use alternatives to remove residues of electronics assembly manufacture and ceramic header fabrication. Alternative manufacturing processes could eliminate the need for solvent cleaning of precision optical components. Ultimately, DOE will eliminate CFCs and chlorinated hydrocarbon solvents from its production cleaning processes altogether.[77]

Recent Legislation

In recent years, Congress and several state legislatures have enacted legislation to advance the pollution prevention ethic. For example, the 1990 Clean Air Act Amendments allow sources of hazardous air pollutants to take a six-year deadline extension for the requirement to install maximum available control technology (MACT)—if the sources make a permanent voluntary 90-percent reduction of those pollutants below 1987 levels in advance of regulatory action. Dozens of site managers have informed EPA of their intention to make deep voluntary emission reductions.

The Pollution Prevention Act of 1990 garnered less attention than the clean air legislation, but it established a waste management hierarchy with priority given to source reduction. It also required EPA to advance industrial pollution prevention using the following measures:

- Identifying measurable goals;
- Improving measurement, data collection, and access to data;
- Assessing existing and proposed programs and identifying barriers;
- Offering grants for state-level technical assistance programs;
- Requiring more data from toxic emitters;
- Identifying opportunities to use federal procurement to encourage source reduction; and
- Establishing awards programs.

Consistent with ongoing activity, the Pollution Prevention Act emphasizes the reduction of industrial hazardous wastes and states that techniques may include changes in equipment or technology, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control.

The Oil Pollution Act of 1990 addresses the wide-ranging problems associated with preventing, responding to, and compensating for oil pollution by creating a comprehensive regime for dealing with tanker- and facility-caused pollution. It sets new standards for crew licensing and manning, mandates contingency planning, broadens enforcement authority, enhances federal response, and adds new research and development. The Oil Pollution Act also mandates double hulls and includes a number of provisions on liability and compensation for pollution events.

State-Level Actions

At least 14 states, including Massachusetts, Oregon, Illinois, and New Jersey have passed legislation to limit the use of toxic substances and/or reduce hazardous waste generation. The state laws vary widely in details, but all of them establish technical assistance (TA) programs and information clearinghouses—another reminder that a key to success in pollution prevention is access to technological know-how.

The National Roundtable of State Pollution Prevention Programs is one focal point for information exchange among the states. In an effort to strengthen member programs and move beyond information exchange, the roundtable at its 1990 meeting established four workgroups: information sharing, data collection, program effectiveness, and training.[78]

Most states offer some form of technical assistance to industries interested in reducing waste. Effective state TA programs, like pollution prevention programs generally, have the following elements:

- An articulated philosophy or approach;
- Strategies to engage senior managers and workers at companies;
- An array of information services including a database, publications, and training;
- Capability to conduct on-site audits;
- Partnerships with key research institutions, universities, and community colleges; and
- Positive incentives such as awards.

State TA programs generally have small staffs and limited budgets. Resources are often extended through partnerships with major local universities. Tennessee's program employs retired engineers trained in pollution prevention by the University of Tennessee. Rhode Island has a continuing relationship with the University of Rhode Island, which trains undergraduate and graduate engineering students for assessment teams. The services of recently retired or student engineers tends to lower costs, ensure familiarity with emerging technologies, and enhance the pollution prevention ethic in university curricula.

Several states clearly emphasize the economic benefits of pollution prevention. Rhode Island's TA teams offer an on-site audit and assessment to companies that may then adopt or reject the state's recommendations. Since the recommendations might be ignored even if they are technically and economically sound, the program emphasizes early development of contacts with the company president or plant manager.[79] The Ohio Technology Transfer Organization, which operates the state's waste reduction TA program, is funded by the Ohio Department of Development. New Jersey, Minnesota, Ohio, Tennessee, and Massachusetts are among the states that offer governor's awards for exemplary corporate approaches to pollution prevention.

Education and Training

Because the pollution prevention ethic requires integrating environmental concerns from the outset of any activity, education and proper training are essential. In 1990 governmental and nongovernmental environmental education programs were expanded for both children and adults.

Educators generally agree that individuals exposed to good information throughout their pre-school, elementary, and high school training are more likely later to incorporate learned values into their behavior. Not suprisingly, the 1990 celebration of Earth Day's 20th anniversary stimulated thousands of special activities in elementary, middle, and high schools. Also the national education goals agreed to by President Bush and the 50 state governors in 1989 will encourage educators to stress pollution prevention in school curricula. To help advance the student achievement and citizenship goal, EPA has begun a two-year National Pollution Prevention Environmental Education Project to produce such materials for teachers and students.

The National Environmental Education Act of 1990 strengthened learning opportunities for all ages but focused especially on young students and their teachers. The act authorized the creation of a special teacher recognition program—the Presidential Awards for Excellence in Environmental Education. The act also established an EPA Office of Environmental Education and a private foundation to leverage private funds for such programs. Under the act, EPA will work with private or-

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The National Environmental Education Act of 1990 focused on environmental literacy among youth and adults—a major factor in pollution prevention.

ganizations to develop environmental education materials and curricula and train environmental educators; provide grants to local school systems, colleges, and universities to develop environmental education programs, including internships; create other national awards in several categories; and create two advisory groups.[80]

At institutions of higher education, environmental technology is often thought to mean control devices or approaches to remediation. Indeed, environmental engineering still is taught as a distinct discipline in universities. Such thinking is inadequate as the nation demands a more integrated approach to environmental and economic issues. Students and practitioners of pollution prevention will therefore benefit from an education in systems integration with some specific knowledge of the biochemistry of pollution, the relation of design to energy use and productivity, and the detailed technical engineering for the process being designed or operated. Environmental engineers will be more effective if they understand some economics, management, law, and public policy.

As environmental management becomes key to corporate competitiveness, the nation is strengthening programs in higher and continuing education. University business and engineering schools, state technical assistance programs, private consulting firms, trade associations, and government are among the organizations offering seminars, workshops, and courses addressing pollution prevention and clean technology. The following 1990 efforts are only a sampling:

- **University of Tennessee Center for Industrial Services.** The center used interactive teleconference technology to present its waste reduction training programs to a national audience. The 1990 teleconference, *Waste Reduction Assessment and Technology Transfer*, attracted 1,113 participants at 65 sites in 24 states. The next teleconference will address solvents usage, substitution, and distillation.[81]

- **NACEPT Education and Training Committee.** In 1990 Tufts University in Medford, Massachusetts, and the EPA National Advisory Committee for Environmental Policy and Technology cosponsored a University Presidents' Roundtable, focusing on environmental management, sustainable development, and university curricula, both at home and abroad. The committee also supports development of the Management Institute for Environment and Business, which funds and uses research on the environmental literacy of corporate employees and graduate business students.[82]

- **Tufts Environmental Literacy Institute.** The Institute, funded by grants from EPA, Allied-Signal, Inc., and Union Carbide Corporation, offers Tufts faculty environmental knowledge and skills to use in curricula revision. The program integrates environmental themes into all courses instead of specific electives, since environmental decisions are made by all disciplines: business leaders, attorneys, engineers, economists, scientists, and consumers.[83]

- **Stanford University Graduate School of Business.** Each year, the school's Public Management Program selects a public management initiative, pursuing a topic in the setting of "a free marketplace of ideas." The 1990-1991 initiative is "Investing in the Environment." Students focus on problem-solving and integrate environmental management themes across many disciplines, with a variety of guest speakers, seminars, and projects. Professors tend to integrate what was learned in these initiatives into subsequent courses.[84]

Advancing Pollution Prevention Technology

A state of "productive harmony" between humans and nature, established as a goal by the National Environmental Policy Act of 1969, would in all likelihood draw nearer if humans found ways to prevent, not just treat, pollution. But as the United States has learned from 20 years of environmental policymaking, pollution is not easily prevented. To actually prevent pollution, the nation must continuously design, build, manage, and refine technology for that purpose in an institutional setting that promotes such efforts.

Fortuitously, the policies needed to foster pollution prevention technology are those that foster technology in general. The strengths and weaknesses of the United States in global technology competition are the same for pollution prevention technology. A concurrent challenge, for the future and for the world, is to provide clean and efficient technology at prices that compete with the dirtier or less efficient alternatives.

Barriers to Prevention Technology

The 1990 report from the National Academy of Engineering (NAE) addressing global technology[85] stated that the U.S. basic research enterprise is unsurpassed. The U.S. pool of technical talent is unmatched, and the scale of technical creativity is enormous. A review of pollution prevention efforts is consistent with this assessment. Greater prevention is not hindered by a lack of technology; rather, very large gains are possible with what is currently known and available.

NAE also identified the country's technological weaknesses, listed here in boldface, with a CEQ appraisal of how they relate to pollution prevention in standard type:

- **Underdeveloped Relationships Between Industry and Academia.** Evidence suggests that academia could better emphasize pollution prevention in providing graduates with requisite skills for industry.

- **Chronic Underinvestment in Infrastructure and Plant.** This factor delays capital investment for pollution prevention equipment.

- **Limited Technical Transfer Both Inside and Outside the Firm.** As demonstrated in numerous cases, information transfer is essential to successful pollution prevention efforts.

- **Underdevelopment of the Workforce Potential.** Inadequate workforce organization, training, and participation hinders prevention, ranging from shop floor suggestions to the effective adoption of new techniques.

In general, NAE found that U.S. weaknesses are a failure to adapt and adopt and not a failure of creativity. This analysis applies equally to pollution prevention.

The overlap between pollution prevention and technological competitiveness is evident in other ways. A 1990 report by the Department of Commerce[66] on emerging technologies of significant economic potential through the year 2000 included many that CEQ finds relevant to pollution prevention and energy efficiency:

- Advanced materials, both for corrosion resistance and pollution avoidance in several applications;
- Superconductors that promise energy efficiency gains;
- Semiconductors needed for contaminant controls;
- Computer-integrated manufacturing, better sensors, and artificial intelligence, which could lead to more efficient manufacturing processes; and
- Biotechnology, which has the potential to replace many chemical and mechanical processes with simpler direct manufacturing techniques.

The report also listed existing technologies of growing importance, such as "smart" buildings, chemical catalysis, power generation, and radiation processing.

The DOC report found barriers to U.S. competition in these emerging technologies, such as the high costs of capital and prototype demonstrations. The prototype barrier is especially troublesome because the multidisciplinary nature of emerging technologies is often too expensive for any single firm to bear. Benefits potentially accrue to so many firms that individual firms are unwilling to undertake research and development alone.

Yet another barrier with overlapping impacts on technology generally and pollution prevention specifically is the problem of excess regulation. Both the regulated and regulating communities are frustrated by dissonant pollution control laws and complex permitting procedures, which tend to discourage innovation and cost-effectiveness in pollution prevention.

Solutions

Measurement and Policy Formulation

Producers want to know the rules of the road before investing in the latest approach to pollution reductions. Regulatory uncertainty only adds to technological and market uncertainties. The concept of pollution prevention is sound but may not invite investment if laws and regulations provide only for mandatory control technologies, with little flexibility or few incentives for voluntary innovation.

A primary challenge is the issue of measurement. The pollution prevention approach depends on decentralized innovation and execution and therefore requires public participation to ensure progress toward a quality environment. Measurement and verification of such prevention is a difficult proposition for all the diverse economic activities conducted in the United States, but clearly more comprehensive data are needed for the design of better programs.

As better measurements are developed, some policymakers may be tempted to impose mandatory pollution cuts based on the latest data, such as the Toxics Release Inventory, overlooking the technical and economic imperatives of specific industries or processes. Such an approach would mark a retreat from attempts to harness market forces to integrate the environment and economics.

Case-by-case consideration of industry proposals by regulators is another potential approach to pollution prevention. However this approach could place regulators in the position of dictating corporate decisions. Nor is it likely that government can match the technical and financial resources of the private sector for assessing thousands of production processes.

A promising solution involves greater education, communication, and research among policymakers and the regulated community to allow a cross-fertilization of ideas and greater mutual understanding. Private-sector experts can help formulate cost-effective pollution reduction strategies and share with regulators and congressional staff the responsibility of setting economic and environmental objectives. An obvious example involves the American chemical industry, which enjoys a world leadership position, a favorable balance of trade, and a highly respected corps of technical engineers. As one of the nation's leading consumers of energy and producers of toxics and as one of the national leaders of the prevention movement, the chemical industry has the opportunity to promote more cost-effective environmental programs if policymakers provide the proper climate.

Technology Promotion

The U.S. Technology Policy issued by the White House Office of Science and Technology Policy in 1990[87] is currently the blueprint for U.S. technology development. The policy mobilizes the private sector and the public to pursue global economic competitiveness of U.S. firms, given a basic reliance on the free enterprise system. Because pollution prevention depends on developments in all technology, the policy has special relevance for the prevention movement.

Among other things, the policy document focuses on the need for a trained quality workforce; a long-term investment climate; better translation of technology into timely, cost-competitive products; efficient technological infrastructures including information transfer; and a legal and regulatory environment that provides stability for innovation and does not pose unnecessary barriers to private investments in research, development, and production.

Federal, state, and local governments, industry, and academia all have roles to play. At the federal level, the following responsibilities apply:

- Providing a stable legal and regulatory environment that decreases investment risk, removes outmoded regulations that stymie innovation, and promotes industrial competitiveness;
- Supporting basic research and participating with the private sector in precompetitive research, when uncertainties are too great to permit assessment of commercial potential; and
- Strengthening science and math education, transferring federally funded research and development, and cooperating with state-level programs.

Such policies would attack the barriers to American competitiveness generally and pollution prevention specifically.

Conclusion

Pollution prevention, highly process-specific by nature, is easily described but harder to define. Clearly, however, the nation is moving beyond an era of remediating gross pollution toward an era of simultaneous economic and environmental progress. As this occurs, the nation's environmental measurements, regulations, and expectations for policies must be realistic and adaptable to a complex set of problems. Simple prescriptions for environmental objectives are often the wrong prescriptions, or at least they are rarely the most effective solutions. Strategies are needed that focus not only on isolated elements and priorities but also on the dynamics of larger systems. Pollution prevention's decentralized ethic is in harmony with the nation's traditions and strengths. Pollution prevention is a promising strategy and an exciting technical challenge.

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In his 1940s conservation classic, A Sand County Almanac,[1] *the American forester and ecologist Aldo Leopold memorialized those early settlers who grew hay in meadows adjoining Wisconsin marshes:*

> *Man and beast, plant and soil lived on and with each other in mutual toleration, to the mutual benefit of all. The marsh might have kept on producing hay and prairie chickens, deer and muskrat, crane music and cranberries forever.*

But the next wave of settlers began to drain and fill the marshes:

> *They did not include soil, plants, or birds in their ideas of mutuality. The dividends of such a balanced economy were too modest. They envisioned farms not only around, but in the marsh.*

The Sand County farms failed, the prairie chickens died out, and the cranes are today endangered.

CHAPTER 4

LINKING ECOSYSTEMS AND BIODIVERSITY

Plant and animal communities, such as Leopold's crane marshes, are valuable national assets. Managing such communities as integral parts of functional ecosystems may be the most efficient--and cost-effective—way to assure survival for cranes and thousands of other U.S. species currently at risk. Such species include plants and animals with recreational value (such as wildflowers and waterfowl) and others of commercial import (such as medicinal plants and seafood). The long-term wellbeing of ecosystems can be ignored only at a nation's great peril. Domestically and worldwide, it is a healthy environment that makes wealth possible. And ecosystems—the functional units formed by plant and animal communities as they interact with their physical environment[2]—are the key to ecological health.

Since the first settlers began clearing the wilderness, conversion of undeveloped lands to human use has been a part of American culture. But, beginning with Yosemite and Yellowstone in the last century, the United States has set aside areas to preserve America's natural heritage. Today, scientists recognize that ecological health depends on maintaining a diversity of living forms on developed lands as well. The current task is to manage not only scenic set-asides, but the larger regional ecosystems that such sites occupy along with developed areas. By using natural or seminatural areas as models to understand how ecosystems function, the nation can ensure that human actions remain compatible with ecological health.

Armed with new knowledge about ecosystems, the nation is moving from managing isolated fragments of the landscape toward an ecological treatment of the whole. Viewing the American landscape as an intricate pattern woven from a diversity of living forms in the complex aggregations that are ecosystems—with developed and undeveloped areas intertwined—will help meet the needs of humans and of other species on which humans ultimately depend.

Biodiversity encompasses not only the variety of distinct species and the genetic variability within them but also the ecosystems they inhabit.[3] Managing lands and waters to ensure that the landscape in which humans live, work, and play is biologically diverse and ecologically healthy will involve tradeoffs and adjustments, as do all environmental policies. Given the potential consequences of reductions in biodiversity, its maintenance is of great concern to the nation.

The United States is a leader among nations in numbers of plant and animal community types—from tropical rainforests in Hawaii and Puerto Rico to freshwater marshes in the Midwest to arctic tundras in Alaska.[4] Today, however, the biological wealth of the United States is in decline, as is such wealth in other nations. Loss of biodiversity is thus both a domestic and a global concern. The United States can continue its tradition as a world leader in conservation by demonstrating a commitment to biodiversity at home as well as abroad.

This chapter focuses on the nature and value of biodiversity. It also explores how ecosystem management can help fulfill the diversity mandates of the National Environmental Policy Act (NEPA) and other U.S. laws designed to assure a healthy and functioning environment.

Loss of Biodiversity: Domestic Concerns

Mass extinctions of species and destruction of ecosystems are not problems restricted to the Tropics. A close-up look at U.S. plant and animal communities reveals the following somber facts:

- In the nearly 500 years since Columbus sailed to the New World, approximately 500 plant and animal species are known to have become extinct in the United States, including the Roosevelt elk, the California grizzly, and the great auk.[5] Today the U.S. extinction rate is already unnaturally high when compared with geological records and promises to accelerate rapidly.

- The U.S. Fish and Wildlife Service and the National Marine Fisheries Service currently list nearly 600 U.S. plant and animal species as threatened or endangered and another 4,000

Table 4-1.—Federal listings,* recovery plans, and critical habitats for threatened and endangered U.S. plant and animal species plus candidate species, 1990.

CATEGORY	ENDANGERED	THREATENED	TOTAL	SPECIES WITH RECOVERY PLANS
Mammals	53	8	61	29
Birds	74	11	85	69
Reptiles	16	17	33	25
Amphibians	6	5	11	6
Fishes	54	33	87	44
Snails	3	6	9	7
Clams	37	2	39	29
Crustaceans	8	2	10	5
Insects	11	9	20	12
Arachnids	3	0	3	0
Plants	180	60	240	120
Total	445	153	597**	351***

Total endangered U.S. species	445	(265 animals, 180 plants)
Total threatened U.S. species	153	(93 animals, 60 plants)
Total listed U.S. species	597	(358 animals, 240 plants)
Total U.S. species with designated critical habitats	108	(83 animals, 25 plants)
Total candidate species	3,700	(1,600 animals, 2,100 plants)

*Maintained by the U.S. Department of the Interior, Fish and Wildlife Service, and the U.S. Department of Commerce, NOAA National Marine Fisheries Service, in compliance with the Endangered Species Act.

**Separate populations of the following species listed both as endangered and threatened are tallied twice: gray wolf, grizzly bear, bald eagle, piping plover, roseate tern, green sea turtle, and olive ridley sea turtle. For purposes of the Endangered Species Act, the term "species" can mean a species, subspecies, or distinct vertebrate population. Several entries also represent entire genera or even families.

***Of the 276 approved recovery plans, some cover more than one species, and a few species have separate plans covering different parts of their ranges.

Source: Department of the Interior, U.S. Fish and Wildlife Service, *Endangered Species Technical Bulletin* 15(11):16 (December 1990).

species await consideration (see Table 4-1). Within the past decade, at least 34 species, subspecies, or vertebrate populations have become extinct while awaiting consideration for federal protection. (It should be noted that most endangered species cases do not result in significant economic dislocations. In the vast majority of cases subject to consultation under Section 7 of the Endangered Species Act, federal agencies are able to identify a "reasonable and prudent" alternative for the activity under review.)

- Other estimates place the number of plants alone that face extinction within the next decade at 700.[6]

- A recent 50-state inventory suggests that a total of 9,000 U.S. plant and animal species may be currently at risk.[7] The problem is national in scope, with every region of the country reporting losses of native species (see Table 4-2). More than species are being lost. Whole plant and animal communities—integrated, resilient systems—are threatened.

Table 4-2.—Top 20 U.S. threatened and endangered animal species and top 20 plant species in order of federal and state expenditures for recovery, 1989.

SPECIES	STATUS	HISTORIC U.S. RANGE
Animals		
1. Bald eagle	E,T	43 states
2. Brown or grizzly bears	T	48 states
3. Red-cockaded woodpecker	E	South
4. American peregrine falcon	E	Alaska, West
5. Gray wolf	E,T	47 states
6. Whooping crane	E	Rocky Mountains to North Carolina and South Carolina
7. Southern sea otter	T	Washington, Oregon, and California
8. Florida manatee	E	Southeast
9. Black-footed ferret	E	West
10. Piping plover	E	Great Lakes to Caribbean
11. Kirtland's warbler	E	West Indies
12. Least Bell's vireo	E	California
13. Florida panther	E	Louisiana-Arkansas and East to South Carolina-Florida
14. Puerto Rican parrot	E	Puerto Rico
15. California condor	E	Oregon and California
16. Humpback chub	E	West
17. Mississippi sandhill crane	E	Mississippi
18. Colorado River squawfish	E	West
19. Bonytail chub	E	West
20. Atlantic ridley sea turtle	E	East Coast
Plants		
1. Tumamoc globe-berry	E	Arizona
2. Western prairie fringed orchid	T	Midwest
3. Northern wild monkshood	T	Iowa, Wisconsin, Ohio, and New York
4. Eastern prairie fringed orchid	T	Midwest, Virginia, Pennsylvania, New Jersey, New York, and Maine
5. Prairie bush-clover	T	Iowa, Illinois, Minnesota, and Wisconsin
6. Aleutian shield-fern	E	Alaska
7. Missouri bladderpod	E	Missouri

Table 4-2.—Continued.

SPECIES	STATUS	HISTORIC U.S. RANGE
8. Blowout penstemon	E	Nebraska
9. Arizona cliffrose	E	Arizona
10. Santa Ana River woolly-star	E	California
11. Minnesota trout lily	E	Minnesota
12. Todson's pennyroyal	E	New Mexico
13. Rhizone fleabane	T	New Mexico
14. Texas bitterweed	E	Texas
15. Mesa Verde cactus	T	Colorado and New Mexico
16. Palmate-bracted bird's beak	E	California
17. Large-flowered fiddleneck	E	California
18. Slender-horned spineflower	E	California
19. Knowlton cactus	E	Colorado and New Mexico
20. Swamp pink	T	Georgia to New York

Note: E = endangered, T = threatened.
For the top 20 animal species, recovery expenditures ranged from $750,000 to $3 million per species; for the top 20 plants, the range was from $19,000 to $1 million per species.

Source: U.S. Department of the Interior, Fish and Wildlife Service, *Federal and State Endangered Species Expenditures: Fiscal Year 1989*, (Washington, DC: DOI Fish and Wildlife Services, 1990).

- Hawaii, California, Texas, and Florida—the nation's most biologically diverse states—are all experiencing declines in natural communities. In Texas, nearly one-third of the plant and animal communities recently inventoried are at risk; as are over one-fifth of such communities in California and nearly half in Florida. In Hawaii, over half of all natural communities are at risk.[8]

- Old-growth forests and tallgrass prairies—two diverse and resilient communities that once defined the U.S. landscape—survive now only in isolated fragments.[9]

- The ecological health of the Florida Everglades is in jeopardy (see Everglades case study).

- Since the 1700s the area of the lower 48 states has lost more than half of its wetlands to conversion and construction; seven states have lost more than 80 percent of their original wetlands.[10] Wetlands are particularly diverse communitities that provide significant economic benefits by supporting commercial fisheries and providing recreation, flood control, and pollution abatement. They also serve as habitat for one-third of the nation's endangered species.

- Polluted runoff from rural and urban sources is degrading vital U.S. watersheds, such as the Chesapeake where striped bass and American shad are reduced and aquatic vegetation is restricted to a fraction of its original range.[11]

- Commercial landings of fish and shellfish along southeastern coasts have decreased by 42 percent since 1982. Between 1972 and 1988 habitat destruction and incidental bycatch reduced bottomfish levels in the Gulf of Mexico by 75 percent.[12]

- The Southeast is losing not just species but whole groups of freshwater mussels that serve as key elements in aquatic food chains.[13]

- Populations of estuarine-dependent fish species off U.S. coasts are at an all-time low, and 30 percent of the freshwater fish in North America, north of Mexico, are considered at risk.[14]

- Waterfowl populations have declined by 30 percent overall since 1969, and mallards and pintails, while not federally listed as threatened or endangered, are down by half or more since mid-century.[15] In 1990 the U.S. Fish and Wildlife Service designated Florida's dusky seaside sparrow as an extinct species. This wetlands-dependent bird was a victim of pastureland conversions.

- Among the many U.S. bird species experiencing sharp population declines or local extinctions are Kentucky warblers, wood thrushes, and scarlet tanagers. The global aspect of biodiversity becomes evident, as birds that summer in the United States lose their winter habitats in the Caribbean or Central America. Fragmentation of U.S. habitats and related effects are also major factors in songbird decline.[16]

At the same time that development raises the standard of living, it can contribute to a biosimplification capable of threatening that very standard. No nation can afford to lose its biological wealth—that panoply of individual species, of genetic variation within species, and of distinct physical settings each with its own complement of biota.[17] The declines described here are indicators of malfunctioning ecosystems that bode ill for the nation and for the world.

S.C. Delaney, EPA

Mallard populations in the United States are down by half since midcentury.

An Emerging Solution: Ecosystem Management

Natural resource management, even where piecemeal, has slowed the degradation of ecosystems, and the Endangered Species Act has rescued some species from extinction. However, the loss of biodiversity continues. A vigorous response to the decline of individual species—based on the Endangered Species Act—remains essential, but the nation also needs new strategies to protect natural communities and biodiversity.

One strategy is to manage sites not as isolated parcels but as part of larger ecosystems. Such management integrates human actions into the environment by considering impacts on multiple scales—for instance, on an immediate site, within a larger ecosystem, and across larger regional systems. Public agencies are exploring this approach, as are conservation groups and private industries (see private lands case study). Increasingly, natural resource managers are coming to view heavily altered, seminatural, and natural areas as interdependent parts of large regional ecosystems.

Ecosystem management strives to maintain the integrity of the basic ecological unit. Piecemeal management—ignoring the interdependence of parts of an ecosystem that happen to be separated by political boundaries or by lines of land ownership—can lead to environmental and biological decline.

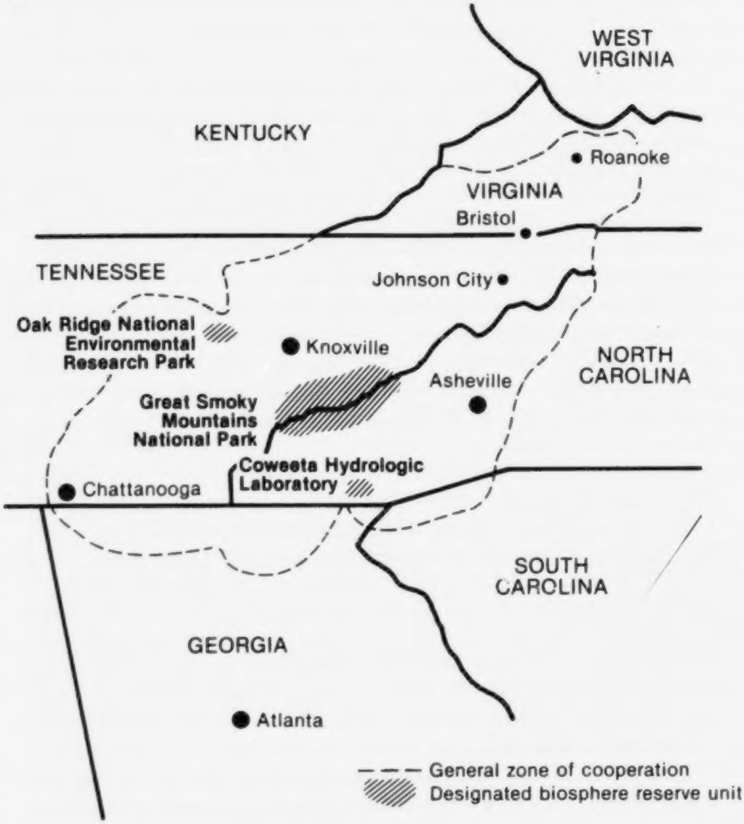
This phenomenon is occurring not only on lands open to development but also in America's most cherished protected areas. An example is the Great Smoky Mountains National Park, renowned for the biological richness of its forests and other plant communities—but today under siege. European wild boars, escaped from a private game preserve, have invaded the park and are damaging the forest understory and displacing native species. Further, the park is home to a healthy breeding population of black bears, but when the bears venture outside the protected boundaries, they are subject to intense hunting pressure that could threaten the population.

Park managers may confer with state officials on such management techniques as hunting seasons and licenses, but they have lacked a mechanism that would allow cooperative management of the regional ecosystem in which the park is located. This situation is changing. In 1988 Great Smoky Mountains National Park joined with other federal agencies to form the Southern Appalachian Man and the Biosphere Cooperative (see Table 4-4). Within a general zone of cooperation (Figure 4-1), public and private land and water managers can now share in joint decisionmaking on an ecosystem scale. For example, they plan to reintroduce the locally extinct red wolf, whose diet will likely include young wild boar. Reintroduction of a predator with an extensive home range would not be possible without the cooperation of all natural resource managers in the ecosystem.

Today scientists, policymakers, regulators, and natural resource managers are recognizing that managing isolated parts of an ecosystem is ineffective. In response, they are advocating cooperative management of regional ecosystems by public and private partners. Their motivation is clear:

- **Neither public lands nor protected areas alone can maintain biodiversity.**[19] Public lands constitute a third of the total land base in the United States, but many plant and animal community types are still not adequately represented,[20] and those that are do not necessarily have protected status. Even within protected areas, such as national parks and wilderness areas, management can not be effective without considering the interactions between protected and multiple-use areas—public and private. Until biodiversity becomes a recognized value across large regional ecosystems, biosimplification will continue.

Figure 4-1.—Southern Appalachian Biosphere Reserve, established in 1988.


WEST VIRGINIA
KENTUCKY
Roanoke
VIRGINIA
Bristol
TENNESSEE
Johnson City
Oak Ridge National Environmental Research Park
Knoxville
NORTH CAROLINA
Asheville
Great Smoky Mountains National Park
Coweeta Hydrologic Laboratory
Chattanooga
SOUTH CAROLINA
GEORGIA
Atlanta
— — — General zone of cooperation
▨ Designated biosphere reserve unit

Source: Southern Appalachian Man and the Biosphere Cooperative, "The Man and the Biosphere Program," (Gatlinsburg, TN: SAMAB, 1990).

- **Development is reaching the borders of protected areas.** In the past, undeveloped land surrounded many of the nation's parks and preserves, and thus entire ecosystems remained undisturbed. Today, many protected areas are becoming isolated nature islands in a sea of development.

- **Piecemeal environmental management does not adequately protect ecosystems.** Separate government programs address land use, nonpoint source pollution, major point sources, wetlands, and a host of other environmental concerns. Failure to integrate such programs makes it difficult for land and water managers to achieve their goals.

CASE STUDY

The Florida Everglades: A Divided and Endangered Ecosystem

The Everglades is a prime example of the need to manage an ecosystem as a functional unit to maintain the integrity of its various parts. The freshwater swamp, located at the southern tip of the Florida peninsula, stands last in line in a 250-mile long watershed whose headwaters rise in the central part of the state. The Everglades has been subject to manipulation that has diminished and polluted waterflow, threatening plant and animal species and the future of the swamp itself. Conversion of land and diversion of water—without considering downstream consequences—has led to a malfunctioning of the entire ecosystem.

The watershed begins south of Orlando in a series of spring-fed lakes that drain into the Kissimmee River, which originally meandered 100 miles through marshland to the vast shallow Lake Okeechobee. Periodic lake overflow sent a 50-mile-wide sheet of water seeping through the Everglades, which originally began on the southern banks of the lake. Before the turn of the century, developers began draining the swamp, and farmers were soon calling the muck soil "black gold" for its high yields of sugarcane and vegetables.[18]

With more of the swamp disappearing each year, conservationists led by Marjorie Stoneman Douglas called for preservation of the remaining wilderness, and in 1947, the Everglades National Park was dedicated. The state set aside acreage between the park and the lake as water conservation areas. Throughout this century, increasing population pressure brought increased demands for flood control. Canals and levees were built to divert water from now-settled areas, and in 1961 the Army Corps of Engineers began a project to replace the Kissimmee River with a wide straight canal. Flood protection encouraged additional development.

Runoff from new farms and pastures in the area added nutrients and other pollutants, and without marshlands to act as filters, the runoff flowed directly into Lake Okeechobee. When excess nutrients began to cause algal blooms in the lake, the state diverted water, which eventually reached wildlife refuges and the national park. In 1988 the federal government sued the state over resulting environmental damage, and the state countersued.

Severe droughts have added to wildlife declines in the Everglades, and Florida's population continues to grow, increasing the interdependence of people and parks. A regional ecosystem view, including such efforts as reflooding the Kissimmee's former riverbeds and wetlands to restore the hydrological cycle and the purchase by the federal government of 106,000 additional acres for Everglades National Park, may help restore the ecological stability upon which the prosperity of the state depends.

To manage lands and waters for human needs and for those of other species, the nation requires both natural and altered systems. Natural plant and animal communities interact to form diverse, stable, and resilient ecosystems that provide a sustained flow of beneficial services. Although intensively managed systems, such as agriculture and forestry, can simplify the biota of a site and can be costly to maintain, the nation's economy depends on them. A landscape view of biodiversity can accommodate both kinds of land uses. Regional approaches that recognize the continuous interactions between altered and natural areas can help maintain biodiversity.

For many years now, Congress has recognized the value of diversity and the critical role of ecosystems. The National Environmental Policy Act of 1969 (NEPA) provides the broadest such mandate, by requiring that the federal government "maintain, wherever possible, an environment which supports diversity. . . ."[21] In addition to NEPA, 28 other federal laws relate to maintaining diversity[22] and a host of others to conserving ecosystems. Among these are the following three examples:

- The Endangered Species Act of 1973 includes in its purpose "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved. . ."[23]

- The National Forest Management Act of 1976 requires that management plans for the national forests "provide for diversity of plant and animal communities,"[24] and

- The Surface Mining Control and Reclamation Act of 1977 states that mining operations shall "establish . . . a diverse, effective, permanent vegetation cover of the same seasonal variety native to the area of land to be affected."[25]

The history of environmental protection is one of continued recognition of the value to human existence of a clean, healthy, and functioning environment. It is also the history of continued creativity in developing solutions. Even in the contentious field of endangered species management, accommodation has been possible in the vast majority of cases. Creativity and the will to put solutions to work are essential traits, if the United States is to reverse losses in biodiversity.

Diversity, Ecosystems, and Biological Health

In the 1960s as scientists studied the growing problems of pollution, their respect for the resilience of natural plant and animal communities increased. They began to seek ways for humans to benefit from such communities without destroying them—for ways to use natural resources to meet human needs without disrupting the basic functioning of ecosystems. In this effort, ecologists have studied the interactions within plant and animal communities and between such communities and the environment. They have identified the diversity of living forms that facilitates these interactions across a range of scales:

- **Genetic Diversity.** Variation occurs between individuals and populations of the same species, based on the genetic traits they inherit.
- **Species Diversity.** The component parts of ecosystems are not only large and conspicuous plants, birds, fishes, and mammals but also less conspicuous species such as insects, mosses, algae, fungi, and bacteria.
- **Ecosystem Diversity.** An array of plant and animal communities and their distinct physical settings exist across the nation and the globe.

As scientists advanced the world's understanding of the value of biodiversity, the need to promote and protect it gradually became evident. In 1990 a number of federal agencies took part in a dialogue on biological diversity, organized by the Keystone Center. The dialogue resulted in a recognition of the value of biodiversity to the nation and on the need to manage regional ecosystems for it.[26]

Values of Biodiversity

Advocates for protecting biodiversity often cite pragmatic reasons for their positions, and the practical consequences of biodiversity loss do promise to be severe. However for many Americans, ethical and esthetic reasons are just as compelling. Respect for the wonder of creation and a sense of moral responsibility are strong American values, and enjoying the beauty of nature is a national pastime. Americans expect, both of themselves and of their institutions, stewardship of the environment to maintain the nation's ecological soundness.

Species and Genepools

Biological diversity encompasses a vast number of species—plants, animals, fungi, and microorganisms and their genetic heritage—many

S.C. Delaney, EPA

Genetically diverse populations are equipped to cope with environmental change.

of which provide direct benefits to the nation. For example, a diversity of species here and abroad serves U.S. agriculture by providing a reservoir of genetic traits that crop and livestock breeders may need in the future. The shrinkage of plant genepools available to crop scientists may be one of the most immediate threats posed by the loss of biodiversity. Yet even within the United States, the vast majority of domestic plants have not been examined in any systematic way for potential benefits.

Native species provide valuable products in addition to commodities such as wood and paper and crops such as cranberries and pecans. For example, in 1990 the American Cancer Society supported efforts by environmental groups to nominate the Pacific yew, an evergreen native to the Pacific Northwest, for listing under the Endangered Species Act.[28] The yew shows promise in the treatment of several types of cancer, yet its dependence on forest types under rapid conversion has led to its decline.

CASE STUDY

Private Lands: Industry Acts to Protect Biodiversity

In 1990 Waste Management, Inc. (WMI), a large multinational waste management firm, issued a policy statement declaring the company's commitment to "no net loss of wetlands or other biological diversity on the Company's property."[27] The firm's Executive Environmental Committee, in consultation with public agencies and with the assistance of the World Wildlife Fund/Conservation Foundation, has developed operational procedures for its local managers. The company has employed an environmental consulting firm to prepare conservation plans for several of its sites.

In preparing recommendations, these consultants compiled data on the geology, hydrology, soils, environmental conditions, and ecological characteristics of the sites prior to making field inventories. Local ecologists are assisting the company in carrying out conservation plans. The two following pilot sites are in the United States:

- **Port Arthur, Texas.** This 5,000-acre WMI site contains a closed 442-acre hazardous waste disposal facility and one of the world's largest operating hazardous waste incinerators. Located near state and federal wildlife refuges, the property is in a central flyway for migratory birds. Its large expanses of pastureland and freshwater marshes are frequented by the fulvous whistling-duck and various wading birds. The company's conservation options for the site include protecting wetlands, managing grazing, and planting to improve wildlife habitat.

- **Ft. Myers, Florida.** On the southern half of a 600-acre site, Waste Management, Inc., operates an active sanitary landfill with a life expectancy of two years. The property is adjacent to a cypress slough preserve, and the northern half has a mix of cypress swamp, slash pine, saw palmetto, early successional shrub, and pasture. The company's conservation options for the Ft. Myers site include improving habitat for endangered species such as the red-cockaded woodpecker and the bald eagle, controlling exotics such as Brazilian pepper and melaleuca trees, and expanding cypress communities.

Waste Management, Inc., and The World Wildlife Fund/Conservation Foundation also are seeking new ways to manage private lands for biodiversity. An upcoming report will emphasize strategies that private sector managers can use to accomplish the following objectives:

- Identify properties with fragile ecosystems that should not be acquired for development, and
- Identify ecosystems on currently owned industrial properties that warrant specific management for biodiversity.

The yew is not an anomaly. In 1984 Americans purchased $8 billion worth of prescriptions with active elements extracted from higher plants.[29] Human dependence on diversity goes beyond the obvious. In addition to medicines, plant and animal species provide fibers, gums, spices, dyes, resins, and oils.[30] Americans also benefit directly from the productivity of coastal and estuarine systems. Ecosystems that are essential to the survival of living marine resources have an annual economic value to society approaching $14 billion, including $5.5 billion in commercial landings alone.[31] Without doubt, threats to biodiversity threaten human welfare.

Biodiversity also affords flexibility in the face of environmental change and variation. Genetic diversity can bestow this flexibility on both managed and unmanaged systems. A genetically diverse population has a number of ways to cope with environmental change,[32] and thus even rare genes can have survival value for the population as a whole. With environmental changes unpredictable, an individual or even a species just getting by under existing conditions might thrive should those conditions change.[33] Diversity is also beneficial in stable situations. For example, different strains of ponderosa pine or Douglas-fir thrive on north-facing slopes, while other strains thrive on south-facing slopes.

Genetic uniformity associated with population decline can threaten the survival of some species. As remaining individuals interbreed, genetic defects may further weaken the population. Captive breeding programs to rescue endangered species now recognize this problem. A program to breed the endangered Puerto Rican parrot succeeded in increasing the numbers of individual birds, but forest managers observed genetic defects in parrot offspring.[34]

The technologies that produce genetically uniform organisms such as hatchery fish or clonal fruit and timber trees offer the benefits of controlled productivity but also the risks of uniform susceptibility to disease and changing environmental stresses. Controlled breeding and, more recently, advances in biotechnology have the capability of producing genetically diverse organisms as well, although such techniques have not been widely applied.

Ecosystem Services

Aside from the value of any single species or the benefits of any single product, healthy ecosystems—either natural or altered systems that retain their basic functional integrity—collectively provide life-support services free of charge for the nation and the planet. A sampling of these services follows.

- **Soil Building.** Soil is a living community, formed by plants, animals, and microorganisms as they move, take in food, release wastes, and reproduce—creating soil from parent rock and their once-living bodies.[35] Both managed and unmanaged ecosystems can build soil, although intensive agriculture and forestry can change soil structure and reduce fertility over time.

- **Erosion Control**. Rainfall—a primary mechanism of erosion—loses its destructive force when captured by leaves or needles, cushioned by ground litter, or slowed by the thick mass of roots in ecosystems such as forests or grasslands.[36] Rainfall on exposed ground runs off directly, carrying away valuable topsoil.

- **Nutrient Availability**. Without the actions of countless organisms, many of them microscopic, the cycling of nutrients from air through living creatures and back again through soil and water could not occur. Two examples follow.

  - Most plants depend on intricate associations between their roots and certain soil fungi for the transfer of nutrients essential to growth. These associations, or mycorrhizae, allow the plants to absorb far more nutrients than they could unaided. Land-use practices such as monocropping and clearcutting can disrupt these systems, making it impossible for plant communities to maintain themselves.

  - Nitrogen is a major plant nutrient, and shortages often limit plant growth. However, nitrogen gas in the atmosphere is useless to living organisms, until it is fixed—incorporated into nitrogen-containing compounds—commonly by bacterial action. Healthy, diverse ecosystems contain a variety of nitrogen-fixing bacteria in nodules on plant roots, scattered throughout the soil, and in certain lichens. These bacteria are responsible for the availability of all nitrogen except that supplied by fertilizers, and the maintenance of natural communities depends on them.

- **Carbon Storage**. Recent concern over the rate of addition of carbon to the atmosphere, based on predictions of resulting global climate change, has focused attention on the carbon-storage properties of plants. Plants absorb carbon from the atmosphere and release oxygen, and plant communities, such as forests and grasslands, store significant amounts of carbon in the form of standing biomass, fallen leaves, litter, dead and downed trees, and underground root material—both alive and dead. Existing forests with their standing biomass, as well as reforestation and afforestation, can provide carbon sinks to help control atmospheric carbon.

- **Hydrological Cycles.** Plants absorb water through their roots and leaves and transpire it through their pores, creating a critical link in regional moisture regimes. Forests, grasslands, and wetlands regulate streamflow, filter water, and control flooding. Examples abound where human development has disrupted this balance with unhappy results (see Everglades case study).

- **Pest Management.** Natural systems characteristically have mechanisms that control pest outbreaks; mechanisms that are missing from intensively managed systems. For instance, the majority of insects found in young forests are destructive leaf-eaters, but old-growth forests support a greater diversity of insect species, among them insects that feed on leaf-eaters.[37] Insect-feeding birds are also most numerous in older forests. With the decline of old-growth forests, the nation may be losing a reservoir of insect and bird species that feed on damaging insects. For similar reasons, the removal of hedgerows and woodlots in agricultural regions may lead to less rather than more crop production.

- **Linkages.** Ecosystem services are the products of networks of relationships, not all of equal strength, and not all direct and linear. Some species—decomposers in particular—are critical links about which little is known. Others, called keystone species, play leading roles in regulating the abundance of other species in the same community. For example, populations of starfish and sea otters have shown dramatic shifts upon removal of a single species from their communities.[38]

Causes of Loss

Humans have had large-scale impacts on the environment with corresponding consequences for biodiversity. All of the following factors are significant in the decline of U.S. biodiversity,[39] but physical alteration is currently the most pervasive:

- Physical alteration of the environment both on land and in coastal and near-shore areas;
- Chemical stress, including acid deposition and excesses of ozone, nutrients, and pesticides;
- Direct taking, such as large incidental fish bycatches during commercial seafood harvesting;
- Introduction of exotic species that invade natural communities and displace native species; and
- Plastics in the aquatic environment that trap or are ingested by fish, birds, and mammals.

U.S. biodiversity is being threatened at all levels—genetic, species, and ecosystem. Narrowing of genetic bases and species loss often go hand in hand, and both are increasingly caused by ecosystem conversion, fragmentation, and simplification. These three forms of human alteration constitute major threats to biodiversity, both domestically and worldwide.[40]

Conversion

Human development has usurped places where native plants and animals once lived. Farms, subdivisions, and shopping centers have replaced more diverse plant and animal communities, and construction and roadbuilding have divided wildlands into smaller and smaller fragments. Conversion to other land uses has an obvious effect on biodiversity, but two kinds of partial alteration—fragmentation and simplification—are also of concern.

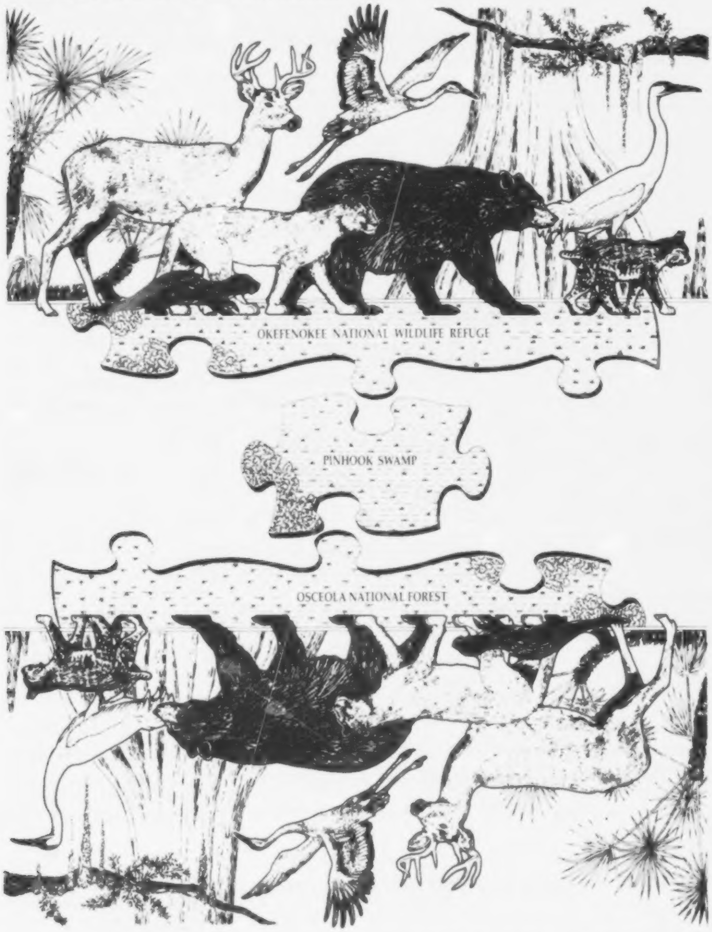
Fragmentation

Dividing an ecosystem into isolated patches creates barriers. When a river is dammed to create a reservoir, fish migrations are blocked or, at best, slowed. Clearcuts within a forest create open areas, with differing temperature and moisture regimes and reduced cover. Such alterations can function as barriers to dispersal and population mixing of some species. Fragmentation also exposes the interiors of remaining patches to external physical and biological factors called edge effects that can benefit some species but harm others. Species diversity is usually reduced, not increased, by fragmentation since species adapted to conditions found in the interior of larger patches are often lost.[41]

Songbirds in newly created edge areas are subject to nest predators and brood parasites that occur in higher densities near the edge of forests than in the interior. The Kirtland's warbler, a bird that requires deep woods, has been driven to near extinction as forests are cleared in patches, allowing the edge-tolerant brown-headed cowbird to invade the forest and lay its eggs in the warbler's nest.[42]

Land and water managers can alleviate detrimental edge effects by retaining large contiguous blocks of habitat, and they may be able to mitigate some effects of fragmentation by linking separate areas with nature corridors or bridges (see Figure 4-2). In the Southwest, the Bureau of Land Management is protecting and restoring riparian corridors along streams, seeps, lakes, marshes, and large springs to connect key habitats for wildlife.[43] Ensuring the retention of such corridors and, where necessary, restoring lost linkages are emerging techniques in managing for biodiversity. President Bush's tree planting initiative has potential to help alleviate ecosystem fragmentation.

Figure 4-2.—Pinhook Swamp corridor purchased by The Nature Conservancy and the USDA Forest Service to provide a 15-mile land bridge between Okefenokee National Wildlife Refuge in Georgia and the Osceola National Forest in Florida.



Source: Illustration by M.R. Clark, copyright 1990 Defenders of Wildlife, printed with permission.

Simplification

Simplification is, by definition, loss of diversity. Variety in an ecosystem can take many forms: more species, more complex food webs, greater three-dimensional structure. For example, a forest with many plant species can support a diversity of associated animal life.[44] Simplification can result from direct human action, such as removal of fallen trees. Fragmentation also contributes to simplification—for instance, by altering the distinctive environmental conditions associated with deep forests. Finally, conversion often equals simplification if it involves selecting for one or a few species. Table 4-3 illustrates the loss of diversity that results from converting an old-growth forest to an inten-

Table 4-3.—Comparison of attributes of old-growth forests and intensively managed tree plantations.

ATTRIBUTE	OLD-GROWTH FOREST	TREE PLANTATION
Land		
Structure		
Canopy	Uneven; many gaps	Even; dense
Cavities in trunks	Many	Few or absent
Subcanopy trees	Various heights	Absent or small
Shrub layer	Uneven; dense in clumps	Even; often sparse or absent
Epiphytes	Abundant on trunks and large branches	Sparse or absent
Snags	Uneven; small to large	Even; few or no large snags
Logs	Uneven sizes; many large, many decay classes	Even; few or no large logs except possible remnants of natural forest
Overall structure	Complex; heterogeneous; much coarse woody debris	Simple; homogeneous; little coarse woody debris
Carbon storage	Higher	Lower
Microclimates		
Light level at forest floor	Uneven; sunny in light gaps	Even; low
Temperature and moisture on forest floor	Uneven	Even
Species diversity		
Trees	Higher	Lower; often one species
Animals	Higher	Lower
Fungi	Higher	Lower
Nutrient pathways		
Nitrogen fixation by epiphytes and in logs	Exceeds atmospheric inputs	Little or none
Nitrogen from early successional trees and shrubs	High	Absent due to vegetation management
Disturbance regime		
Wind damage	Individual trees	Individual losses rarer, large-scale blowdowns more common
Damage from insects and pathogenic fungi	Usually individual trees or small groups	Epidemics can affect whole stands or larger areas
Streams		
Structure		
Logs in streams	Many; some large	Few; none large
Sediments	Diverse, from silts to cobbles	Uniform
Species diversity		
Invertebrates	Higher	Lower
Salmonid fishes	Higher	Lower
Amphibians	Higher	Lower

Source: Adapted from Norse, E.A., *Ancient Forests of the Pacific Northwest*, (Washington, DC: The Wilderness Society, 1990), pages 158–159.

sively managed tree plantation. The table is illustrative and compares extremes; many managed forests are more diverse than tree plantations, and young natural forests may be less diverse than old growth. Natural systems can absorb a certain amount of conversion, simplification, and fragmentation. Such activities are not, in the abstract, unacceptable. It is possible, though, to overload a system.

An Evolution in Management Scale

Natural resource management and environmental protection have produced two recurrent trends—an increased understanding of how human actions affect the environment[45] and a maturation in how society controls those effects.

Early settlers recognized the damage caused by unconstrained market hunting when game became harder to find. Later on, city dwellers could see that uncontrolled coal burning had direct effects on human health and wellbeing. Responses were likewise direct—states enacted bag and creel limits and restricted hunting and fishing to certain seasons. Cities adopted limits on burning, especially during certain weather conditions. Game limits were complemented by statewide game management programs and, later, by adoption of the Endangered Species Act. Increasingly, analytical and technological sophistication led governments—federal, state, and local—to adopt air pollution standards, at first designed to address direct, local effects. More recently, society has come to recognize—and now respond to—acidic deposition (commonly known as acid rain).

With the recognition of such problems as loss of biodiversity, climate change, and ecosystem degradation, society finds itself grappling with global issues that challenge human knowledge and creativity. The scope of human effects on the environment often overwhelms project-by-project attempts to understand or reduce impacts.[46]

Current Management Approaches

Today, natural resource managers are designing programs that consider the wellbeing of multiple species within an ecosystem. Environmental policies also are taking a regional focus with geographically targeted programs that address a number of issues within a particular region.

Species Management

The original focus of wildlife management was popular, harvestable game species. Threatened and endangered species received attention as more and more plant and animal species became extinct.[47]

Although foreshadowed by the Lacey Act and the Migratory Bird Treaty Act,[48] the Endangered Species Act was the first formal, national recognition that each species makes a unique contribution to the tapestry of life on this planet and that the nation should, when possible, avoid tearing that fabric.[49] Clearly, endangered species programs form an essential part of biodiversity protection.

The act recognizes the value of habitat and the need to manage on an ecosystem scale. It authorizes designation of critical habitat—areas essential to the preservation of endangered species and in need of special management[50]—and calls for the preparation of recovery plans for listed species (see Ash Meadows case study). However, such plans are not enforceable.[51]

The endangered species problem is daunting. At present rates, it would take 50 years to list those U.S. species now considered to be in danger. The program has financial limitations, as well. Full recovery for all currently listed threatened and endangered U.S. species would cost an estimated $4.6 billion, yet annual funding has been less than $10 million.[52]

The Endangered Species Act comes into play when options and alternatives are limited. Species eligible for listing are, by definition, either dangerously reduced in number or subject to strong forces that will result, if unchecked, in their extinction. Frequently, habitat for such reduced populations exists only in isolated fragments that cannot support long-term viable populations of a species. Loss of genetic diversity and lack of suitable habitat limit captive recovery efforts.

The act also comes into play when human options are limited. Projects are often already well-defined and represent substantial program or financial investments before sponsors can identify impacts on threatened or endangered species. Lack of a comprehensive source of information on the habitat needs of endangered species means that such reviews will be undertaken on a case-by-case basis and, thus, late in project development.

The nation also has devoted a great deal of effort to protecting and propagating game species. Fees on hunting and fishing equipment fund game and fish enhancement projects and statewide wildlife planning.[53] Without careful review, such projects could expand the range of game species without regard for detrimental effects on nongame species. Congress passed the Fish and Wildlife Conservation Act of 1980,[54] also known as the Nongame Act, in response to concerns over the fate of species not valued for their recreational potential. The act authorizes federal support for state-based wildlife planning, but it has never been funded.

Both endangered species protection and game management have value in protecting biodiversity. The Endangered Species Act, in particular, is crucial as it preserves the basic elements of species diversity—distinct and unique species.

The Nature Conservancy

Ecosystem management can help ensure that the habitat needs of multiple species are met.

Project Impact Management

Congress passed NEPA and a host of specific laws to ensure that federal agencies could both understand and control the environmental effects of human actions. While the emphasis of most such laws and regulations is on abating or avoiding specific impacts, NEPA requires that managers look at the entire array of environmental effects of their projects. By requiring such analysis along with public involvement, NEPA has fostered a greater understanding of the magnitude of human effects on the environment.

CASE STUDY

Ash Meadows: An Ecosystem Recovery Plan

Named for the ash trees that distinguish it from surrounding creosote-bush communities, Ash Meadows is a spring-fed oasis in the midst of the Mojave Desert. Its 50,000 acres straddle the California-Nevada border northwest of Las Vegas. A series of natural springs active since prehistoric times supports an isolated relict biota.

The meadows' most famous inhabitant, the endangered Devil's Hole pupfish, averages about an inch in length and was the center of a controversy that led to a Supreme Court decision. Devil's Hole is an Ash Meadows spring located in a network of limestone caves dedicated as the Devil's Hole National Monument in 1932. The monument is managed by the National Park Service.

In addition to the Devil's Hole pupfish, Ash Meadows is sole habitat for 27 other unique plants and animals of which 13 species are federally listed as threatened or endangered.

In the 1970s when a ranching operation in the area caused a decline in discharge from Devil's Hole, the National Park Service brought legal action. The case went to the Supreme Court, which in 1976 ruled in favor of protecting the national monument from groundwater pumping. The ranch subsequently ceased operations, but development in the area continued to alter springs not protected by the Park Service. In 1984 The Nature Conservancy purchased acreage, which it resold to the U.S. Fish and Wildlife Service for the Ash Meadows National Wildlife Refuge. The Bureau of Land Management also set aside public lands for the refuge.

Today, this Area of Management Concern consists of over 23,000 acres, encompassing most of the habitat of the threatened and endangered species. The refuge includes lands managed by the Bureau of Land Management (9,243 acres), the Fish and Wildlife Service (12,438 acres), the National Park Service (40 acres), and private lands (1,371 acres). The Ash Meadows Recovery Plan, completed in 1990, considers the entire ecosystem rather than focusing on each of the 13 threatened and endangered species. The first step in recovery was to secure the water-dependent habitat. Other steps include removing exotic plants and animals that have invaded the area, controlling herds of wild horses, and protecting the meadows with fencing, stream barriers, and interpretive signs. Captive breeding programs for the endangered species will supplement on-site ecosystem management.

Most environmental laws focus on controlling pollution in one specific context—air, water, or the disposal of waste, for example. Despite the overarching, inclusive NEPA framework, the narrow focus of these laws combined with competing interests and multiple objectives leads most project sponsors to focus on statute-driven lists of impacts. This case-by-case, issue-by-issue approach often leaves pervasive values—such as biodiversity—unprotected. In addition, lack of comprehensive information on the distribution, abundance, representation, and degree of destruction of species and natural communities in the United States significantly hampers comprehensive analysis.

Managing by Area Not Impact

The limitations of species-based management and narrowly focused project-by-project, permit-by-permit analysis have led to the development of geographically targeted approaches. Based on watersheds or other ecological units rather than political boundaries, such approaches provide the tools and conceptual structures for ecosystem management. Geographically targeted management programs often involve different levels of government with private conservation and development interests and focus on full characterization of an area and on a variety of protective mechanisms for it.

The Next Step

An evolution is occurring in the scale of analysis and understanding of environmental concerns. The corresponding shift in management rests on the conclusion—reached in programs as diverse as game management and water pollution control—that, while everything may not be hitched to everything else, a narrow conception of an issue can lead managers to ignore essential elements of the system in which the issue is embedded. The result of such narrow conceptions is often avoidable impacts and unintended consequences. The ecosystem approach is proving more useful for predictive and management purposes[55] than the more narrowly focused approaches that preceded it (see the Yellowstone case study).

To more fully understand human impacts on the environment, ecologists are recommending that resource managers conduct analyses at a scale sufficiently large to include the ecological boundaries of an issue. By basing risk assessments on functionally defined regions, they can account for the physical and biological processes that affect or will be affected by a human action.[56]

CASE STUDY

The Greater Yellowstone Ecosystem: Regional Management in Action

Yellowstone National Park, with its geysers, spectacular landforms, abundant wildlife, wilderness areas, and developed recreation sites, is one of the jewels of the national park system. It has been designated both a Biosphere Reserve and a World Heritage Site by the United Nations Scientific, Educational and Cultural Organization (UNESCO).

But Yellowstone is not an island. The Greater Yellowstone Ecosystem, comprising the contiguous mountain region in and around Yellowstone Park, encompasses nearly 19 million acres, of which only 2.5 million acres are national park lands. The rest includes portions of six national forests and lands owned and managed by the Bureau of Land Management, Fish and Wildlife Service, the states of Montana, Wyoming, and Idaho, and private individuals.

Nor can Yellowstone be managed as an island. In the early 1960s the Park Service and the Forest Service each recognized the limits of their ability to meet statutory mandates without the cooperation of their neighbors and formed the Greater Yellowstone Coordinating Committee. Other agencies participate regularly in discussions on policy for the region.[57]

Management of the Yellowstone elk herds that cross administrative boundaries as they move from summer to winter ranges, coordination of grizzly bear and wolf policy, ensuring the integrity of the geothermal deposits that create Old Faithful, managing transportation and recreation, and the need to ensure a healthy and diverse economic base motivated creation of the committee.

Managing the Greater Yellowstone Ecosystem requires balancing the diversity of land ownerships, the variety of management objectives, and the difficulty in gaining acceptance of proposals that reduce management prerogatives. But a common vision and a common base of information can guide independent decisionmakers toward the goals of ensuring ecosystem integrity and maintaining biodiversity, while integrating these objectives into the fabric of economic life.

Ecosystem Management: An Approach Not a Formula

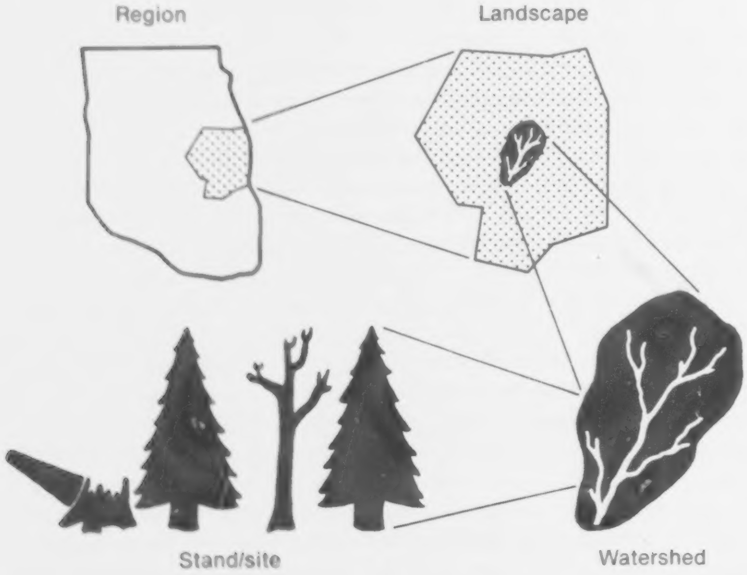
Ecosystem management has aspects of both process, "conceptualization in a systems framework,"[58] as well as substance, "ensur[ing] that all plants and animals are maintained at viable populations in native habitats and that basic ecosystem processes . . . are perpetuated."[59]

The core concept of the approach is management in an ecosystem context. Such an approach requires that human actions—whether programs to restore the health of the Chesapeake Bay or plans for timber harvest in Mount Hood National Forest—account for the basic ecological context in which they take place. That context includes ecological composition, structure, and function—the defining elements of an ecosystem.

Employing the concept involves consideration of scale. Individual actions have effects both on an immediate site, for example, a forest stand, and as part of larger patterns of change, for example, in a watershed. Likewise, patterns of change within a watershed will have consequences for the regional landscape. Ecosystem management requires that decisionmakers at all scales—site, ecosystem, and region—be cognizant of effects of their actions in the larger scheme[60] (see Figure 4-3).

Just as delineating the boundaries of an ecosystem depends in large measure upon the issue under analysis, so does the definition of what will be studied or managed. Basic to the ecosystem management approach is placement of the immediate concern in a larger context. By way of example, looking at the larger context could involve changes in management perspective.

Figure 4-3.—Scale in ecological decisionmaking.



Source: Adapted from Salwasser, H., "Conserving biological diversity: a perspective on scope and approaches," *Forest Ecology and Management* 35:79-90 (Amsterdam, The Netherlands, 1990).

- **Broadening Horizons.** Managers can track changes in ecosystems rather than focus solely on target species. For example, forests can be grown as crops, but the crop can be the forest ecosystem,[61] not merely young trees of a single age class. Or, monocultural plantations might be more fully integrated into diverse and healthy regional ecosystems. A broader view also can provide perspective on the relative occurrence or rarity of a particular species or community in a local, national, or even global context.

- **Integrating Efforts.** Managers can make greater efforts to integrate protection programs. As an example, wetlands managers are finding that they need to integrate federal and state regulatory programs, state floodplain and water quality programs, and local zoning, planning, and sensitive area protection. Why? Because wetlands have various landowners —public and private—and unless integrated, actions and programs can neglect key influences or even work at cross-purposes.

The Broader View

Managers in such programs as national forest planning, endangered species recovery, and wetlands protection have good reasons for initiating and embracing techniques that require more analyses, involve more people and agencies, and integrate agency objectives with those of others concerned about the resource. The regulated community, including many developers, likewise is embracing such approaches. For example, developers in California have welcomed the initiation of habitat conservation plans for multiple endangered species as a means of reducing the need for eleventh-hour efforts.[62] And the National Wetlands Policy Forum[63] endorsed state, regional, and local wetlands planning efforts, in response to developers' needs for greater certainty in the permitting process.

The trend toward ecosystem management signals a developing consensus that a broadening of perspectives is essential to success. Whether success is framed as the ability to run a program without constant controversy—a factor that drives at least some endangered species and wetlands planning efforts—or the ability to plan development without surprises, ecology is overtaking narrowly focused decisionmaking.

Current land-use decisions involve different agencies and different levels of government—each with its own sphere of concern and corresponding area of expertise. Each of these units exerts independent authority over proposals by developers and agencies in a sequential fashion. The process is unpredictable and invites conflict and fragmented decisions.[64] Ecosystem management, by considering both natural factors and human institutions, can bring together multiple decisions in a single framework.

Reliance upon broader, more inclusive decisionmaking will neither solve nor preclude all conflicts over allocation of resources. As the participants in the Keystone Dialogue noted, although federal multiple-use lands must continue to meet human needs, the extent, timing, and location of uses may need to change to conserve biodiversity.[65]

The threat of biodiversity loss may change the daily operations of land and water managers. The situation requires a quantum leap in cooperation and communication between interests and across sectoral lines—public/private, science/management, preservationist/developer, federal/state/local, and interagency. Currently such cooperation is time-consuming, difficult, and until participants gain more experience, of uncertain outcome. Statutory and regulatory frameworks—some established under earlier, narrower conceptions of the workings of the natural world—also constrain broad-view approaches. The nation may need to update management systems to ensure that meeting human needs in the short run does not preclude achieving ecological objectives vital to human wellbeing in the long run.

A Sampling of Current Approaches

Though the term biodiversity may be relatively new, the recognition that native species of plants and animals are worthy of conservation is a trademark of U.S. natural resource policy. And though techniques for managing natural resources may change with new ecological knowledge, some techniques that protect ecosystems and promote biodiversity are already in use. Not all approaches aim to preserve biodiversity across all scales, nor do they all focus on ecosystem management. Rather, efforts may be targeted toward maintaining a particular scale of diversity—genetic, species, or ecosystem. Such techniques may be categorized as either off-site or on-site,[66] and ecosystem management has evolved in a number of these programs.

Off-site approaches, such as seed and embryo banks, zoological parks, botanical gardens, and captive breeding programs involve intensive intervention to maintain species or communities outside their natural environment. Off-site approaches serve conservation, for example, by providing convenient storage of germplasm for breeding programs and allowing access to samples of wild species for research and for propagating endangered species.

On-site approaches may have broad objectives, as in maintaining entire ecosystems, or focused objectives, as in ensuring the habitat of a single species within an ecosystem or perhaps across several ecosystems. In addition, some scientists and managers are developing techniques to restore ecosystems and communities, allowing for restoration of reduced biodiversity.

The following section reviews a sampling of off-site and on-site programs and several geographically targeted programs.

Off-Site Maintenance

Maintaining species or communities outside of their natural environment can support on-site management techniques, such as ecosystem restoration.

National Plant Germplasm System

The Agricultural Research Service in the U.S. Department of Agriculture administers the National Plant Germplasm System to provide plant breeders and research scientists with continued access to reserves of genetic material essential to maintaining the nation's major crops.[67] The system is the world's largest distributor of plant germplasm and each year supplies more than 230,000 samples from its collections to more than 100 nations.[68] In addition to storage, the program plants seeds on a regular basis to maintain a fresh supply. In 1990 Congress enacted new legislation to expand the scope of the National Plant Germplasm System with a National Genetic Resources Program to preserve a broader range of genetic resources, including those from animals, insects, and microbial organisms.[69]

Center for Plant Conservation

The Center for Plant Conservation is a private consortium of botanical gardens and arboreta, established in 1984 to rescue native plants. The center maintains a growing national collection of over 400 species of threatened and endangered native plants and cooperates with the Agricultural Research Service on seed storage. It maintains this collection through the cooperation of member institutions, each of which has agreed to bring into cultivation and place into seed storage the most highly endangered plant species of their particular region of the United States.

American Association of Zoological Parks and Aquariums

This network of U.S. and Canadian zoos and aquariums conducts a Species Survival Program for native and exotic wild animals. Until the 1960s zoos and aquariums were consumers of wildlife—when an animal died, they just ordered another specimen from the wild. Today, with species at risk around the world, zoos and aquariums have become major wildlife producers. Of 156 institutional members, 128 have species survival plans for threatened and endangered animals. Member institutions cooperate with public agencies such as the U.S. Fish and Wildlife Service on captive breeding programs for native species including the black-footed ferret, California condor, red wolf, thick-billed parrot, whooping crane, and Puerto Rican crested toad.[70]

American Type Culture Collection

The American Type Culture Collection (ATCC) is a gene library and a national repository for microorganisms. Governed by a board representing 21 scientific societies, the institute collects, propagates, preserves, and distributes cultures of microorganisms, cell lines, animal and plant viruses, and special gene and cellular products. Over 42,000 strains of microorganisms—freeze-dried or in live culture—are available for use in education, research, and various scientific and industrial applications. The ATCC provides technical information and other services to microbiologists worldwide, publishes a catalogue of its holdings, and maintains a computerized on-line database.[71]

On-Site Management

Both public and private sectors are managing properties in ways that can help—or hinder—biodiversity maintenance. Public land managers achieve a variety of objectives, from explicit biodiversity and ecosystem protection to broader multiple-use management that may include strip mining, intensive forest management, grazing, military training, and nuclear energy research.

Protected Areas

Natural areas—public and private—help maintain U.S. biodiversity. Among the larger private programs are The Nature Conservancy reserves with over one million acres in 50 states and National Audubon Society wildlife sanctuaries, with 150,000 acres in 19 states. Many individual private landowners also expend considerable time, effort, and money to protect and carefully manage their land in ways that promote biodiversity. Some conservation groups and states offer registry programs that recognize private efforts and provide technical assistance. Most states and a number of cities manage state and municipal forests and parks, but the federal government is the largest single natural area manager.

Biosphere Reserves

One of the few programs to have biological diversity as a primary goal, biosphere reserves are part of a global network administered by the United Nations' Man and the Biosphere Program (MAB). The MAB Secretariat in the State Department oversees administration of the 46 U.S. biosphere reserves (see Table 4-4) that include federal land, state land, university property, and private reserves; total acreage in reserves exceeds 17 million hectares (44 million acres). The original qualifications for designation—a core of wilderness, a buffer of limited human use, a transition area of mixed uses, and a history of scientific work and educational outreach—still apply but with the realization that management must extend across boundaries to a regional ecosystem. Biosphere reserves began as a designation program to identify outstanding natural areas and encourage their protection, but the program may be entering a more active stage, for the network has the potential to provide monitoring sites in such fields as biodiversity and climate change.

Table 4-4.—United Nations Biosphere Reserves (46) in the United States, 1990.

BIOSPHERE RESERVE	LOCATION	ADMINISTRATION	AREAS	BIOME
			hectares	
Aleutian Islands	AK	USDI/FWS	1,100,943	Tundra Communities and Barren Arctic Deserts
Beaver Creek	AZ	USDA/FS	111,300	Warm Deserts and Semi-deserts
Big Bend	TX	USDI/NPS	283,247	Warm Deserts and Semi-deserts
Big Thicket	TX	USDI/NPS	34,217	Temperate Broadleaf Forests or Woodlands
Calif. Coast Ranges	CA	USDA/FS USDI/BLM,NPS TNC,CA	62,098	Temperate Rainforests
Carolinian-South Atlantic	NC/SC GA	USDI/NPS,FWS DOC/NOAA SC,NC foundations	125,545	Temperate Broadleaf Forests or Woodlands
Cascade Head	OR	USDA/FS	7,051	Temperate Rainforests
Central Calif. Coast	CA	USDI/FWS,NPS DOC/NOAA, CA county, city	404,863	Evergreen Sclerophyllous Forests, Scrub, or Woodlands
Central Gulf Coastal Plain	FL	FL	16,402	Temperate Broadleaf Forests or Woodlands
Central Plains	CO	USDA/ARS	6,210	Temperate Grasslands
Champlain-Adirondack	NY,VT	USDA/FS NY,VT local, private	3,990,000	Temperate Broadleaf Forests or Woodlands

Table 4-4.—Continued.

BIOSPHERE RESERVE	LOCATION	ADMINISTRATION	AREA *hectares*	BIOME
Channel Islands	CA	USDI/NPS	479,652	Mixed Islands System
Coram	MT	USDA/FS	3,010	Mixed Mountain and Highland Systems
Denali	AK	USDI/NPS	782,000	Temperate Needleleaf Forests or Woodlands
Desert	UT	USDA/FS	22,513	Cold Winter Deserts and Semi-deserts
Everglades	FL	USDI/NPS	566,800	Temperate Broadleaf Forests or Woodlands
Fraser	CO	USDA/FS	9,328	Mixed Mountain and Highland Systems
Glacier Bay-Admiralty Island	AK	USDA/FS USDI/NPS	1,515,015	Temperate Rainforests
Glacier	MT	USDI/NPS	410,058	Temperate Grasslands
Guanica	PR	PR	4,000	Mixed Island Systems
H.J. Andrews	OR	USDA/FS	6,100	Mixed Mountain and Highland Systems
Hawaiian Islands	HI	USDI/NPS	99,545	Mixed Island Systems
Hubbard Brook	NH	USDA/FS	3,075	Temperate Needleleaf Forests or Woodlands
Isle Royale	MI	USDI/NPS	54,144	River and Lake Systems Temperate Needleleaf Forests or Woodlands
Jornada	NM	USDA/ARS	78,297	Warm Deserts and Semi-deserts
Konza Prairie	KS	TNC	3,487	Temperate Grasslands
Luquillo	PR	USDA/FS	11,340	Tropical Humid Forests
Mammoth Cave Area	KY	USDI/NPS	83,377	Temperate Broadleaf Forests or Woodlands
Mojave and CO Deserts	CA	USDA/FS,CA USDI/NPS,BLM	1,297,264	Warm Deserts and Semi-deserts
New Jersey Pinelands	NJ	Pinelands Commission complex ownerships	438,210	Temperate Broadleaf Forests and Woodlands
Niwot Ridge	CO	USDA/FS	1,200	Mixed Mountain and Highland Systems

Table 4-4.—United Nations Biosphere Reserves (46) in the United States, 1990.

BIOSPHERE RESERVE	LOCATION	ADMINISTRATION	AREAS	BIOME
			hectares	
Noatak	AK	USDI/NPS	3,035,200	Tundra Communities and Barren Arctic Deserts
Olympic	WA	USDI/NPS	363,379	Temperate Rainforests
Organ Pipe Cactus	AZ	USDI/NPS	133,278	Warm Deserts and Semi-deserts
Rocky Mountain	CO	USDI/NPS	106,710	Mixed Mountain and Highland Systems
San Dimas	CA	USDA/FS	6,947	Evergreen Sclerophyllous Forests, Scrub, or Woodlands
San Joaquin	CA	USDA/FS	1,832	Evergreen Sclerophyllous Forests, Scrub, or Woodlands
Sequoia and Kings Canyon	CA	USDI/NPS	343,000	Mixed Mountains and Highland Systems
South Atlantic Coastal Plain	SC	USDI/NPS	6,125	Temperate Broadleaf Forests or Woodlands
Southern Appalachian	NC,TN	USDA/FS USDI/NPS DOE	215,596	Temperate Broadleaf Forests or Woodlands
Stanislaus-Toulumne	CA	USDA/FS	607	Mixed Mountain and Highland Systems
Three Sisters	OR	USDA/FS	80,900	Mixed Mountain and Highland Systems
Univ. of Michigan	MI	MI	4,048	River and Lake Systems Temperate Broadleaf Forests or Woodlands
Virgin Islands	VI	USDI/NPS	6,130	Mixed Island Systems
Virginia Coast	VA	TNC	13,511	Temperate Broadleaf Forests or Woodlands
Yellowstone	WY,MT ID	USDI/NPS	898,349	Mixed Mountain and Highland Systems

Note: Names of U.S. biosphere reserves do not include administrative designations; biome = largest ecological unit.
Source: U.S. Man and the Biosphere Program, Washington, DC, 1991. Biome types are based on a classification by M.D.F. Udvardy, 1975, see MAB Secretariat, Division of Ecology Services, *Biosphere Reserves*, map (Paris, France: UNESCO MAB, 1987).

Federal Natural Areas

Federal lands managed primarily for natural values include national parks and monuments, wilderness and primitive areas, and wildlife refuges. Management objectives for individual units may not always coincide with protection of biodiversity. For example, the impetus for establishing many national parks was scenic beauty rather than ecological function, and the parks have a dual mandate for conservation and recreation. Many wildlife refuges operate under game management objectives that can conflict with the wellbeing of other plant and animal species, and boundaries of many wilderness areas were established based on wilderness character rather than ecosystem functioning or biodiversity.

Federal agencies have long recognized the value of setting aside areas for the study of natural processes. For instance, the National Science Foundation administers 640,000 acres of Long-Term Ecological Research sites; the Department of Energy has 580,000 acres of National Environmental Research Parks; and the Forest Service has 224 Research Natural Areas that average 1,100 acres and represent most U.S. forest community types.

Although many designated natural areas are small and thus prone to detrimental edge effects and catastrophic natural events, they are nonetheless valuable elements in a conservation strategy. Federal agencies set aside natural areas designated by more than 100 different names, including the following:

- Research Natural Areas,
- National Environmental Research Parks,
- Experimental Forests, Watersheds, and Ranges,
- Experimental Ecological Reserves,
- Ecological Research Areas, and
- Long-Term Ecological Research Sites.

Multiple-Use Lands and Waters

The previous section described areas set aside for preservation in their natural state, but most lands and waters—public and private—are not managed for this purpose. For instance, the Forest Service in the Department of Agriculture (USDA) and the Bureau of Land Management in the Department of the Interior jointly manage 343 million acres or 47 percent of the federal estate under a multiple-use mandate. The Department of Defense manages 18.7 million acres of wildlands (see public-private partnership case study) and the Department of Energy manages 2.1 million acres of land, 95 percent of it undeveloped. Decisions regarding multiple-use lands can be among the most contro-

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CASE STUDY

Public-Private Partnerships: Biodiversity and National Defense Lands

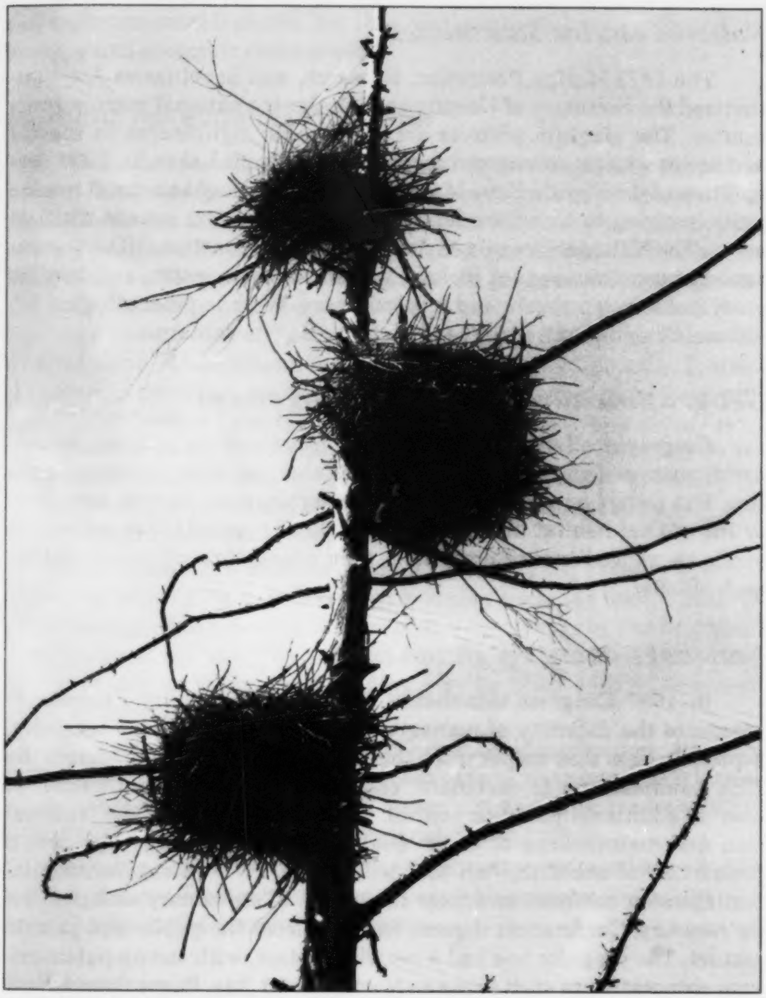
In 1988 the Department of Defense (DOD) and The Nature Conservancy (TNC) signed an agreement "to identify, document and maintain biological diversity on Defense installations."[73] The two groups are now sharing natural resource information and developing automated databases and related geographic information systems. DOD agreed to provide TNC access to Defense facilities and to evaluate the conservation group's recommendations regarding a natural resource inventory and monitoring guidelines. TNC studies and inventories on a host of DOD facilities have led to discoveries of rare or threatened plants, animals, and natural communities. Because training maneuvers can require large buffer areas, military lands are often the largest unfragmented properties in a region. Within the security of the military installation, species and natural communities that have been eliminated by development in surrounding areas survive.

Vandenberg Air Force Base, with 100,000 acres on the coast of southern California, is a missile testing facility that requires vast stretches of open land to minimize possible hazards from aborted missiles. More than two-thirds of the base is in a natural state, and the DOD-TNC cooperative effort has documented several endangered animals, 41 rare plant species, including 15 candidates for federal listing, 350 bird species, 5,000 acres of wetlands, 9,000 acres of undisturbed coastal dunes, relict stands of native bunchgrass, and the largest existing remnant of a globally rare plant, the Burton Mesa chaparral.[74] New management plans include protection for this diverse biota. As ecologists provide the tools for ecosystem management, federal land management agencies—even those with multiple-use objectives as demanding as the Department of Defense—are doing their part to maintain the nation's biodiversity.

versial in the natural resource field. Meeting conservation objectives such as biodiversity, while at the same time meeting other human needs, may require difficult tradeoffs and new management techniques.

The New Forestry

Although intensive forest management can simplify ecosystems, other forestry practices can maintain ecosystem integrity. The USDA Forest Service conducts research on the impacts of a range of management practices, from wilderness management to tree plantations, as well as strategies that involve complete or partial harvest and the maintenance of patches of undisturbed forest.



Forest Service Collection, Natinoal Agricultural Library

Standing dead trees (snags) and downed wood lend structural diversity—an essential part of biodiversity—to forest ecosystems.

Forest Service scientists at the Andrews Ecosystem Research Group in Oregon are advocating what they call the New Forestry.[72] Their focus is on maintaining complex forest ecosystems and not just on regenerating trees. To prevent soil erosion and to benefit wildlife, they recommend that standing dead trees (snags) and fallen trees remain on harvested sites. Large living trees left to prevent erosion can supply beneficial insects to young trees, conserve soil microorganisms, and provide seedstock for regeneration. The New Forestry suggests that humans can use natural systems for commodity production in ways that maintain ecosystem health.

National Marine Sanctuaries

The 1972 Marine Protection, Research, and Sanctuaries Act[75] authorized the Secretary of Commerce to designate national marine sanctuaries. The program protects areas of special significance in coastal and ocean waters, submerged lands, and the Great Lakes. In 1990 designation of the Florida Keys Marine Sanctuary brought the total to nine units, ranging in size from less than 1 to over 1,000 square nautical miles. The National Oceanic Atmospheric Administration (NOAA) manages the sanctuaries that include nearshore, open water, and benthic ecosystems in temperate and tropical areas. Work is proceeding on additional designations, including Monterey Bay in California.

Geographically Targeted Management

Geographically targeted programs focus not on political boundaries, such as federal agency regions, states, counties, or municipalities, but rather on ecological units—estuaries, river basins, corridors, or the critical habitat of a species or group of species. Often not aimed explicitly at biodiversity protection, they nonetheless offer a model for such efforts.

National Estuary Program

In 1987 Congress established the National Estuary Program to recognize the difficulty of managing water quality in major estuaries, especially ones that border more than one state. The law authorizes the EPA Administrator to designate "estuaries of national significance" in need of additional pollution control. The goal is to ensure the "restoration and maintenance of water quality," and "a balanced indigenous population of shellfish, fish and wildlife . . . ."[76] Intergovernmental management conferences assess the health of an estuary and plan for its recovery. Conferences depend on input from the public and private sectors. The program has had a promising start, with strong public-private cooperation in such areas as Narragansett Bay, Puget Sound, Buzzards Bay, and Long Island Sound.

River Corridor Management

In 1968 Congress passed the Wild and Scenic Rivers Act[77] to recognize the need to protect rivers of outstanding scenic, recreational, fish, wildlife, and other values. The act complements national dam-building programs and other river management. The Wild and Scenic River System now includes over 9,278 river miles on 120 rivers. A cooperative effort, the system relies on the actions of private individuals and groups, as well as all levels of government, with assistance from federal agencies.[78] Rather than setting priorities beforehand, the program elicits goals from those involved. Resulting plans recommend protecting valued environmental features, but they also recognize local needs such as housing and economic development.

Planning for Wetlands Protection

Wetlands are valued environmental features frequently subject to intense land-use pressure and various environmental threats. The Clean Water Act addresses this issue with its Section 404 wetlands permitting program. The Environmental Protection Agency (EPA) and the Army Corps of Engineers, which manage the program, have recognized the limitations of a permit-by-permit approach. In response, they have borrowed the concept of "special area management planning" from the Coastal Zone Management Act and are using geographically focused planning to provide a more predictable and protective regulatory process.[79] The Coastal Zone Management Act indicates that a special area management plan (SAMP), in which many interests participate to resolve environmental and development concerns, should "provid[e] for natural resource protection and reasonable . . . economic growth"[80] in a specific geographic area.

SAMPs are often combined with a process called advance identification, in which EPA and the Corps examine wetlands within an area experiencing strong development pressure to determine the ecological significance of the site. The agencies may decide that certain sites may be unsuitable for filling, while others may be filled with little overall harm to the ecosystem.

At present, a combined SAMP-advance identification planning process in the Hackensack Meadowlands area of New Jersey is addressing issues including wetlands use, Superfund cleanups, transportation infrastructure development, and regional housing needs.

By adding an ecosystem focus and connections with other pollution control and development planning efforts, the agencies are applying a broader view to the permitting program.

Habitat Conservation Planning

The drafters of the Endangered Species Act recognized that, at times, the needs of endangered species would conflict with otherwise legal activities. Section 10(a) of the act allows the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to issue permits for "incidental" taking[81] of endangered species, as long as the action is otherwise legal, and the applicant provides a "habitat conservation plan" (HCP). The secretaries of Interior and Commerce may not approve such a taking without a plan showing that the action will not appreciably reduce the likelihood of species survival, the applicant will minimize and mitigate to the maximum extent practicable (including review of alternatives), and the conservation plan has an assured funding mechanism.

By 1990 only about 30 habitat conservation plans were completed or in progress. The first and perhaps best known was the San Bruno Mountain plan that resulted in setting aside 87 percent of the habitat of several rare butterflies, including the federally listed mission blue butterfly in a heavily urbanized area south of San Francisco.[82]

In spite of the relatively few examples, the agencies increasingly recognize that plans need to address all or most of a habitat for listed species in a region, encompassing a range of possible threats rather than focusing on the effect of a single development proposal. The Fish and Wildlife Service recommends that HCPs also address other species that may be listed as threatened or endangered in the future.[83]

HCPs have the potential to become vehicles for identifying—and thus encouraging—all development that could occur without directly or immediately causing a species to become extinct. The HCP process does begin with the application for an incidental take permit—a request to harm in some way individuals of an endangered species—rather than with a species recovery program. The possibility of HCPs evolving into species *reduction* plans rather than species *protection* plans calls for monitoring of the program.

Science, Information, and Inventory

To measure the success of ecosystem and biodiversity efforts, the scientific community must have up-to-date information on the nation's species, populations, communities, and ecosystems. Much data is missing, and the considerable amount that already exists needs national coordination to make it accessible.

A Biotic Base

The nation needs to develop a basic understanding of the biota of the United States to ensure successful biodiversity protection efforts.

- No comprehensive list of domestic species exists even for vascular plants and vertebrates[84] let alone for less visible and less known species. Beyond simple listing and identification of species, information on the abundance, distribution, and habits of the majority of species is lacking.

- The nation has no comprehensive listing of natural communities and no generally recognized scheme for cataloging and naming these communities.

- Significant gaps exist in current knowledge of linkages between ecosystem and landscape processes.[85]

- Current understanding of the ways in which species interact to form ecosystems is inadequate, as is knowledge of the limitations of managed systems to sustain a diverse flora and fauna.[86]

- The nation lacks even regional databases of species of concern or other key ecological variables, and the tools for describing landscape patterns remain experimental.[87]

The lack of consensus on a community or ecosystem classification system provides but one example of the problems encountered in this area. The USDA Forest Service uses a forest cover type system developed by the Society of American Foresters that classifies land by the type of natural forest actually growing on it. Another approach, known as the Kuchler system, uses potential vegetation types to describe the type of vegetation that would ultimately grow on a site if left undisturbed.

No classification system is perfect, and one system varies from another by the objectives of those collecting the data, but the lack of consensus means continued fragmentation of effort.

Gaps in genetic information also hamper conservation efforts, as demonstrated by the unsuccessful captive breeding program for the dusky seaside sparrow.[88] However new information on genetic relationships is resulting from work in the field of genetic engineering, including recombinant DNA research.

In short, the United States lacks fundamental elements necessary to ensure that the nation's actions are in consonance with managing ecosystems and biodiversity.

Integration and Filling Gaps

Despite the gaps, biotic information abounds. For centuries, scientists have developed a considerable, although far from complete, body of information on the biota of the United States. That information exists in museums, universities, and other systematics institutions. Each federal land management agency maintains information on the natural resources it manages. States maintain similar information. Private firms collect information as part of their efforts to comply with federal, tribal, state, and local laws and regulations. Private conservation organizations collect data on areas or species of concern to them.

But no one knows what it all adds up to. No one has integrated the available information or undertaken a comprehensive effort to identify gaps in existing knowledge. Different groups and agencies use different procedures to collect data and different categories and names, even for the same phenomenon. The nation spends large sums to assess specific projects and land-use practices. Such efforts could be more efficient and effective if supported by a complete and accessible source of information on the nature, distribution, abundance, and interactions of organisms and communities.

An example of synthetic work that could support better decisionmaking is the *Flora of North America* program, now being coordinated at the Missouri Botanical Garden. The project will result in a 12-volume inventory of the plants of the United States, Canada, and Greenland, coupled with a digest of expert opinions and a database on plant characteristics.

As valuable as information and inventories might be, scientists, public and private planners, policymakers, and land and water managers must be able to locate, gain access to, manipulate, and present that data in ways that suit their particular objectives. Data sharing requires a full partnership among the thousands of individuals and institutions studying and gathering information on specific organisms or communities. Such a partnership would strengthen decisionmaking at all levels by encompassing a full range of public and private institutions—universities, museums, government efforts, and private programs such as the Natural Heritage Program established by The Nature Conservancy.

Scientists are developing a number of promising uses for computer technology, for example, geographic information systems (GIS). A GIS-based technique called gap analysis enables biologists to integrate information regarding location, density, and diversity of species with information on factors relevant to conservation, such as planned development and protected areas. Such integration presents—in a readily understandable format—opportunities for improving protection.

A Strategy for Conservation Tomorrow

Conserving America's rich biological heritage is a vital responsibility. The nation's health, wealth, and scenic beauty are at issue.

An Evolution in the Conservation of Natural Resources

Maintaining biodiversity requires attention to a broader array of elements within the environment and allows—perhaps forces—the nation to manage cooperatively larger units of the natural landscape. This imperative coincides with the trend in conservation toward working with ecosystems in a landscape context.

The goal of the Endangered Species Act is a grand and vital one—to prevent species from becoming extinct—but the species approach has been likened to a "911 distress line for life forms teetering on the edge"[89] or "emergency room care"[90] with species of concern in dire straits. Most nonendangered or nongame species have no programs to monitor their condition or to avoid placing them in dire straits.

Suggestions that the United States take steps to protect biodiversity are not simply calls for a super endangered species program—a mandate to identify and manage or to one-by-one restore every living thing on Earth, or even in the United States. Such a task would be daunting, indeed overwhelming. The situation calls for a different strategy. Preserving species—the purpose of the Endangered Species Act—is a major element in maintaining biodiversity, and the law itself mandates the management of ecosystems on which the species depend.

Failure to address the ecosystem scale of human impact means that an increasing number of species—adapted to specific habitats—will become threatened and endangered as those habitats become damaged, isolated, or fragmented. Without adequate habitat, recovery of species now on the endangered list is difficult if not impossible. Ultimately, it is not species that humans will need to manage but habitat. An ecosystem-based approach, as described in the Endangered Species Act, can help achieve this goal.

An integrated strategy to conserve biodiversity at all levels will include the following elements:

- Techniques that allow managers to work with a relatively small, manageable number of elements yet achieve the broad goals of genetic, species, and ecosystem diversity. Resource managers need techniques for measuring simple properties that integrate ecological processes over large areas. For example, focused research may allow the condition of an entire watershed to be monitored by measuring specific water quality parameters in a particular stream.[91]

- An information base that is readily available in a form and at a scale that managers can use;

- Techniques applicable to both natural and managed landscapes. Protected lands are critical to biodiversity protection, but the landscape in which humans live, work, and play also can be diverse and ecologically healthy; and

- Identification, and where feasible, restoration of elements and linkages that have been degraded or converted to other uses.

Ecosystem Management and Biodiversity in Policymaking

Many of the elements necessary for improving environmental management are in place.

- Scientists know much about how ecosystems work, far more collectively than is put to use.
- Natural resource managers know much about managing natural systems.
- Analysts grow increasingly sophisticated at predicting how the effects of human actions will ripple through ecosystems.
- The United States has incorporated strong environmental protection objectives into national decisionmaking.
- Significant federal resources are contributing, directly or indirectly, to the conservation of biodiversity. Efforts such as managing protected areas, surveying and monitoring natural resources, managing species and ecosystems, maintaining germplasm banks, and biodiversity research contribute in a direct fashion. Many regulatory efforts, including the Clean Water Act's Section 404 program, contribute as do conserving multiple-use lands, programs of museums and botanical and zoological gardens, and environmental education.

A strategy to conserve biodiversity in the United States will involve all of these elements, each of which exists to some degree in the current federal system. But critical gaps remain.

A National Goal

Many U.S. laws mandate conservation of some aspect of diversity, from the broad mandate of NEPA to the more specific mandates of the Migratory Bird Conservation Act or the National Forest Management Act. Many federal agencies are integrating the concept of biodiversity into day-to-day activities, ranging from staff training[92] to land management planning and assessment. Although found in many places within the federal government, these programs and statutes do not form a coherent, comprehensive framework for assessing or assuring progress toward a common goal, in part because no one has heretofore articulated a goal, such as:

> ***Biodiversity is a national asset for both present and future generations that requires wise use and sustainability. Both public and private sectors in the United States have a role in maintaining and restoring biodiversity for its intrinsic worth, for healthy ecosystems, and for human wellbeing.***[93]

Such a goal need not conflict with a robust, growing economy. In the long run, biodiversity will support a healthy economy. The techniques and examples of management discussed in this chapter suggest that these two goals do not present irreconcilable conflicts.

Continuing Evolution

As public and private land and water managers attempt to incorporate ecosystem management and biodiversity into their planning and operations, it becomes increasingly evident that a comprehensive national biological inventory would facilitate their efforts. Such efforts can continue in its absence, however.

As private firms develop their next strategic business plan, as government program managers consider their next round of planning, and as land managers in both sectors prepare the next unit management plan, they can—within the limits of existing information—consider the broader systems within which their actions take place. They can cultivate connections between adjacent landowners. They can integrate their programs—formally or informally—to sensitize decisionmakers to the effects their actions will have on other programs.

Federal land managers and program administrators can enhance their contacts with tribal, state, and local governments and with the private sector to minimize duplication of effort, lack of attention to necessary factors, and conflicts among goals, objectives, and strategies of different participants.

Every landowner need not attempt to resolve, singlehandedly, the nation's problems of ecosystem fragmentation, conversion, and simplification. But individual decisions can either ameliorate or exacerbate such problems. Understanding regional patterns and recognizing that, in the long run, maintaining healthy, diverse ecosystems is vital to the wellbeing of all Americans will go a long way toward reducing conflict and improving environmental quality.

A National Biological Inventory

Information is critical to conservation. Without an adequate understanding of the status, numbers, distribution, and types of species extant in the United States and of the community associations on which they depend, inevitably, human actions will result in additional loss of biodiversity.

A national biotic inventory will require a more complete knowledge base than presently exists. While biological databases and the expertise they represent in institutions around the United States are impressive, major gaps remain in current knowledge. Deficits exist in understanding even major and relatively well-known groups of organisms in addition to whole categories about which scientists know very little.

Despite the limitations of existing knowledge, cataloging available information would be useful. Creating such a "database of databases"[94] would entail identifying and linking existing information from public and private sources. This would provide access to the best information on a subject, even if that information is, as yet, uncertain and incomplete.

Far more important, however, is a commitment to identify gaps in knowledge and set priorities for filling those gaps, which include the following:

- ■ **Species Classification.** With only 1 percent of U.S. species characterized,[95] additional systematics research is essential; and
- ■ **Basic Ecological Research.** Also needed is fundamental information on the distribution, abundance, and ecological relationships of U.S. species and a comprehensive inventory and classification of ecosystems.

A national biological inventory would provide a mechanism to access results of biodiversity research and management projects, whose total funding is in the millions of dollars. Such an inventory would allow the nation to perform the following tasks:

- Identify and ensure adequate resources for investigations in areas where information is lacking,
- Monitor biodiversity programs, and
- Link, where appropriate, public and private databases, laboratories, and field investigations.

A National Network of Bioreserves

Federal agencies have hundreds of designated natural areas that can contribute to a conservation strategy. Many private landowners also expend considerable resources to conserve their lands. The 1990s offer the promise of greater efforts by the federal government to coordinate protection of public natural areas and to encourage stewardship of private natural areas.

In the 1960s land management agencies established the Federal Committee on Research Natural Areas[96] to build a system of reserves representing the nation's natural land and water ecosystems. In 1974 the National Science Foundation and the Council on Environmental Quality joined the effort and the group became the Federal Committee on Ecological Reserves with 21 federal agency members. The goal was to establish and maintain a network of protected field sites representing a full array of the nation's terrestrial and aquatic ecosystems, but in recent years the committee has been inactive.

Each ecosystem contributes in its own way to the wellbeing of the nation, and in the closing years of the twentieth century, no U.S. ecosystem should become extinct. Today, the potential loss of thousands of U.S. species, primarily because of habitat alteration, demands a revitalized effort to inventory public and private natural areas across the nation, to identify gaps and, where necessary, to provide technical assistance and encouragement. Over the coming year, the Council on Environmental Quality will initiate a dialogue with other members of the Federal Committee on Ecological Reserves regarding the benefits of revitalizing this effort.

A Global Concern

Concern over U.S. biodiversity cannot occur in a vacuum. Around the world, scientists, policymakers, and the public are coming to understand the value of the wealth of life that surrounds and supports all human endeavor and the global threats to it. Unless the international community can reverse the current trend in global biodiversity loss, the rate of extinction worldwide over the next few decades could rise to 1,000 times the normal background rate. The result could be the loss of up to half the species on Earth.[97]

The United States is a world leader in meeting environmental challenges. The conservation of biodiversity need be no different. With the knowledge and willpower Americans have devoted to other environmental matters, the United States can be in the vanguard of nations facing this critical global challenge.

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may flow out. A lake may receive deposition from the atmosphere and detritus carried by animals, yet it functions as a discrete unit. At the other end of the spectrum, scientists are studying large marine ecosystems—discrete oceanic areas in which recurring currents and patterns of nutrient cycling delimit functional units that are more closed than open. The lines of demarcation are not absolute, and defining where one ecosystem ends and another begins may depend on the subject of concern. An ecosystem may be as small as a log or as large as the Chesapeake watershed that extends south into Virginia and north to the headwaters of the Susquehanna River in upstate New York. A system like the Chesapeake may consist of many smaller ecosystems—logs, lakes, and the bay itself.

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E. Hodes, Rails-to-Trails Conservancy

Converting railroad rights-of-way to trails is an example of an action that can affect transportation, energy efficiency, natural resources, and historic preservation. Twenty years ago, Senator Henry Jackson, an architect of the National Environmental Policy Act, foresaw the need to integrate such diverse objectives:

> ***. . . man's ability to survive on this earth and to enjoy quality social, cultural, and aesthetic conditions . . . will turn on our ability to develop policies and decision-making models which integrate environmental concerns along with the full range of other important human values.***[1]

CHAPTER 5

THE NATIONAL ENVIRONMENTAL POLICY ACT

Environmental quality, one of the nation's most pervasive and confounding issues, was, until 1970, considered primarily for public policy purposes in its discrete constituent parts, such as water, soil, and wildlife. The National Environmental Policy Act of 1969 (NEPA)[2] dramatically changed that one-dimensional approach to environmental management by requiring that the totality of environmental quality concerns be integrated comprehensively into federal policymaking and decisionmaking. NEPA as an integrative tool is the subject of the first part of this chapter. Subsequent parts examine recent NEPA trends and selected cases decided in the 12-month period since the last CEQ *Environmental Quality* report.

Integration in Concept and Practice

The twentieth century, according to the late O.B. Hardison, Jr., has been characterized by sporadic "explosions of awareness," one of which unquestionably grew out of the environmental movement of the 1960s and found its ultimate expression in NEPA. "Such recurrent explosions of consciousness," Hardison observed, "do not seem accidental.

They are like a volcanic eruption that suddenly releases enormous energy after a long, invisible buildup of pressure. They suggest the presence of a form of consciousness just under the surface of modern life that emerges whenever the conditions are right."[3]

In the second half of this century, the United States has witnessed not one, but two explosions of environmental awareness. The reverberations of Earth Day 1970, "the catalyst for the creation of the modern American environmental movement," had not dissipated when, on the twentieth anniversary of that explosion, the nation experienced yet another equally powerful blast on Earth Day 1990 that developed into a "huge, global coalition determined to turn the tide in the battle to pull the planet back from the brink of ecological destruction."[4] Many of the same concerns, frustrations, and doubts that ignited the first explosion of environmental awareness more than 20 years ago persist today. Indeed, threats posed by global climate change, deforestation, soil erosion, species extinction, habitat destruction, and a host of other assaults on the environment seem to many observers more menacing today than they did in the 1960s.[5]

Citizens understand now, perhaps better than they did two decades ago but still not completely, that the components of humankind's total life support system are interconnected and that, as a consequence, they cannot approach environmental problems in piecemeal fashion. And today, not unlike 20 years ago, the nation is searching for a comprehensive approach to environmental problems—an approach capable of anticipating environmentally disruptive influences and avoiding them.[6] That, however, is precisely why NEPA was enacted—to deal "with environmental problems on a preventive and an anticipatory basis."[7] But the continuing search for a comprehensive solution to environmental problems invites the question of whether NEPA represents an entirely adequate response to the apparently recurrent or ongoing conditions that spawned its enactment.

The Concept of Integration

NEPA was not intended to respond to any particular environmental "condition." Rather, it marked "an effort for the first time to impress and implant on the Federal agencies an awareness and concern for the total environmental impact of their actions and proposed programs . . . to avoid conflicts of one program objective with others through the mechanisms provided in [the act]."[8] The objectives of NEPA were to be achieved not through widespread government reorganization or through the creation of vast new bureaucracies to manage the environment; nor was Congress prepared to amend the enabling legislation of every agency of the federal government. Instead, NEPA was designed as a statutory supplement to other agency authorizations. While this legislative strategy was an invitation to parochialize administration of the act, Congress believed that existing institutions were capable of managing the environment if they operated "(1) under a coherent national policy . . . and (2) with an expanded understanding of ecological facts and processes."[9] NEPA provided the former and a directive for federal agencies to equip themselves with the latter.

To guard against any tendency on the part of federal agencies to overlook environmental values in pursuing their "narrower, more immediate, mission-oriented goals,"[10] Congress built into the act certain "action-forcing" provisions, including the requirement to prepare a "detailed statement" for every major federal action significantly affecting the quality of the environment.

The authorizations of most federal agencies are grounded in policies, such as agriculture, resource recovery, and economic development, which, on the one hand, contribute to a high standard of living but, on the other hand, are not necessarily consistent with environmental policy objectives. Congress, however, never intended in enacting NEPA that national environmental policy should override other policies. Instead, an accommodation—a balancing of competing policies—is the goal that Congress sought. NEPA represents the government's "expressed determination to move the Nation in a comprehensive manner toward accommodation of the disparate goals of economic growth and preservation of a 'quality' environment."[11] Now Americans increasingly see that, contrary to the view advanced by many academicians 20 years ago, a clean environment and a sound economy can go hand in hand. And although the mandatory provisions of NEPA apply only to agencies of the federal government, Congress believed that achieving the act's lofty objectives is the responsibility of all branches of government,[12] at all levels,[13] as well as the private sector[14] and individual citizens.[15]

Legislative efforts directed at restoring and maintaining environmental quality did not cease with enactment of NEPA, however. On the contrary, NEPA was viewed as providing "a framework for the formulation of specific legislative measures to deal with a wide variety of environmental problems."[16] The 91st Congress, which passed NEPA, also had under consideration "[m]ore than 2,000 legislative proposals . . . having a bearing on environmental matters,"[17] of which 121 were passed and signed into law.[18] Granted, many of the "environmentally pertinent" statutes passed by the 91st Congress—and by succeeding congresses as well—involved so-called "interface areas such as transportation development and landscape preservation. . . ."[19] But a number of statutes that Congress enacted both before and after passage of NEPA[20] go considerably beyond interfacing and establish firm policies with respect to specific areas of environmental quality, all of which serves to illustrate the dilemma confronting every agency of the federal government: how to accommodate environmental quality objectives, as developed in dozens of statutes, while at the same time effectively carrying out its primary mission, a mission that in some respects appears to be at odds with those objectives. In NEPA, however, Congress provided the solution — "[a]n overall policy for the environment . . . which *integrates* [wide-ranging, statutorily mandated] purposes and objectives and which provides for choice when they are incompatible."[21]

The concept of integration is at the heart of NEPA, from its directive for the Council on Environmental Quality (CEQ) on behalf of the President to prepare and transmit an annual report to Congress, designed to integrate environmental data and trends into the legislative process, to its charge that CEQ act as public educator on environmental issues, basically for the purpose of instilling concern for the environment into the nation's social consciousness. For federal agencies, the concept of integration is evident in the act's "action-forcing" procedural requirements contained in section 102, a crucial integrative catalyst, the ultimate goal of which is to blend discordant policy parts into a more harmonious whole.[22] But integration as a goal of the section 102 procedural requirements was not an engrossing concept early in the implementation and administration of NEPA; instead, the nature and extent of the procedural requirements themselves became the cause celebre.

Integration as an Evolving Concept

The conceptual evolution of integration under NEPA has had two fairly distinct stages, and as the act enters its third decade, the nation may be poised on the threshold of yet another stage. The first stage, which grew out of early congressional hearings and debates on a national policy for the environment, extended into the late 1970s when the CEQ regulations became effective. This was essentially a transitional stage in which federal agencies struggled to infuse their decisionmaking processes with the new supplemental basis for policy development—systematic ecology. And as might be expected when "dealing with a new animal,"[23] it was a period marked by controversy and great uncertainty.

Agency implementation of NEPA in the early 1970s was spotty at best and often undertaken without much forethought as to the consequences. Many agencies simply combined the procedural requirements of NEPA "with their existing procedures in the way least disruptive to those existing procedures."[24] This approach to NEPA implementation profoundly affected the act's performance during much of its first decade, primarily by allowing proposals to be developed substantially in advance of environmental analysis thereby limiting the choice among alternatives that could be more compatible with environmental quality objectives. By *adding* the NEPA procedures to, instead of *integrating* them with, existing agency procedures, decisionmaking was also made much more complicated. And because most existing agency procedures had a very narrow, project-oriented focus, an early pattern of attempting to achieve policy balance under NEPA on a nonpolicy, case-by-case basis, developed.

Congressional Intent

Initial difficulties with implementation of NEPA transcended the act's procedures. The problem, according to many observers, centered on the impact statements themselves, not the section 102 procedures which had been endorsed in congressional oversight hearings as *"bold and innovative,"* having *"served to increase research, data-gathering and the development of agency analytic skills. . . ."*[25] But NEPA did not (nor does it today) set out with specificity what it expects in terms of the form and content of the "detailed statements"; ecology, after all, had only recently been introduced as an element of federal decisionmaking. For this reason, the sponsors and supporters of NEPA knew that environmental analysis in all fields of federal activity would have to be carefully nurtured at the agency level. At the same time, however, concern was expressed by Congress *"that some agencies urgently need[ed] the development of entirely new in-house research machinery or broadened assistance of outside consultants in order to carry out adequate environmental analysis."*[26] Satisfying that concern would require that environmental analyses contain "much more detailed information . . . [delivered] in a much more timely manner to help structure the public debate. . . ."[27]

Judicial Concerns

The courts, which had taken an early and active interest in NEPA through their review of agency actions subject to the act, also called for more detailed information in environmental impact statements (EISs). Although the scope of judicial review of agency actions subject to NEPA was related principally to the act's section 102 procedures,[28] courts were not reluctant to find that agencies must go beyond mere procedural compliance and "make a sufficiently detailed disclosure so that in the event of a later challenge to the agency's procedure, the courts will not be left to guess whether the requirements of . . . NEPA have been obeyed."[29] Of course, there was danger that the demand for greater detail in environmental impact statements would invite additional paperwork and cause greater delay in the decisionmaking process. But this result was viewed by many courts as "incident" to their mandate and "a concomitant of the implementation of the procedures prescribed by NEPA. . . ."[30]

The concept of integration had not been emphasized by oversight committees of the Congress or the courts in the very early stages of implementing NEPA, nor did they have a clear understanding of just how that concept fit into the overall environmental review process under the act. Was it a purely mechanical exercise involving, for example, "integrat[ion of] the new guidelines developed . . . by CEQ . . . into existing, highly diversified procedures being applied by the various agencies in existing planning, evaluation and review processes"?[31] Or was more required, including an examination of "basic [agency] authorities to see how the new mandates of NEPA must be integrated"?[32] But even with respect to the more mechanical approach to integration, the role of NEPA was not well understood.

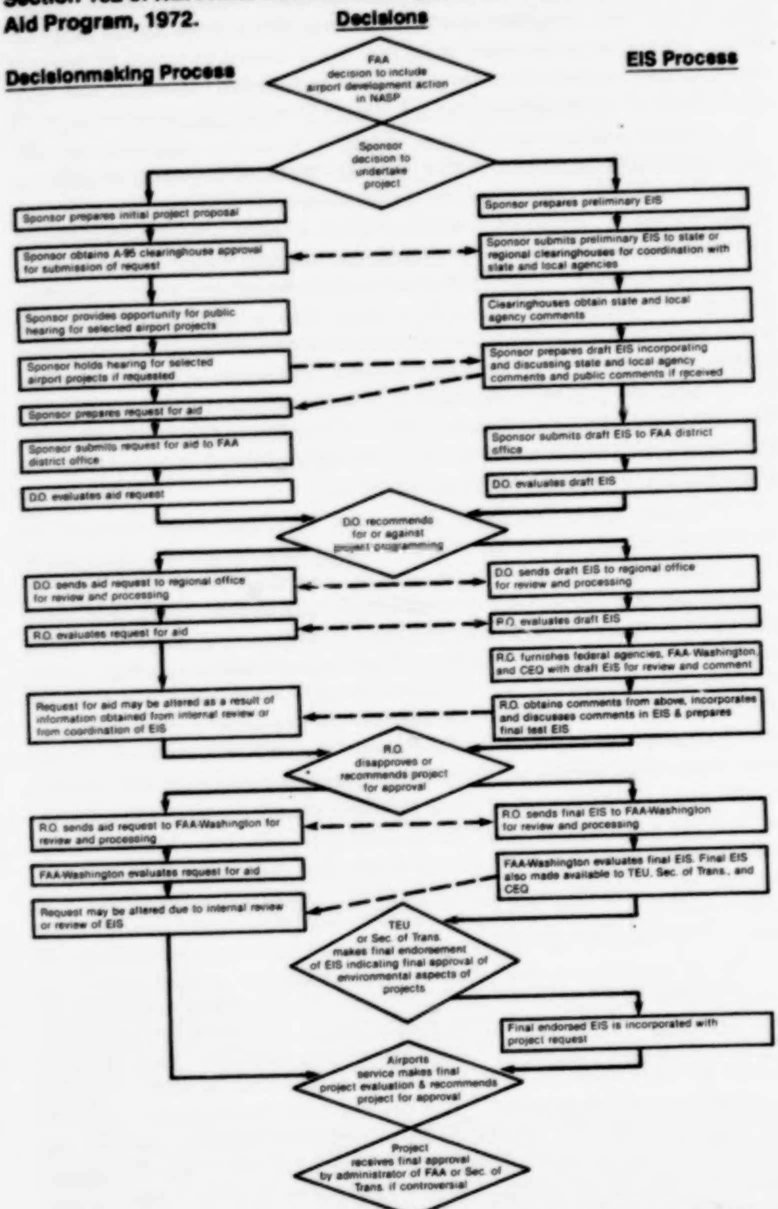
In terms of integrating requirements of existing environmental review laws, such as the Fish and Wildlife Coordination Act, the question presented was whether NEPA should be integrated into the former, as one congressional oversight committee suggested,[33] or, as the court in *Environmental Defense Fund v. Corps of Engineers* determined, whether compliance "with the provisions of [NEPA] in good faith . . . automatically take into consideration all of the factors required by the Fish and Wildlife Act."[34] None of these questions was vigorously pursued, however, because most authorities considered achieving the goals and objectives of NEPA to be more a function of the quantity of information contained in the environmental impact statements as opposed to either the quality of that information or the means through which it could be integrated most effectively into the decisionmaking process.

Agency Responses

Agencies responded predictably to the demands of Congress and the judiciary for greater "detail" in environmental impact statements. They began preparing lengthy, nonanalytic documents that contributed little, if anything, to either environmental quality objectives or to their primary missions. Coupled with development of exceedingly complex systems of review (see Figure 5-1), the tendency of agencies to prepare highly "detailed" statements quickly came to be viewed as the principal source of delay in the decisionmaking process and a prime contributor to increased project costs. Agency excesses in the EIS process generated a rash of early proposals to amend NEPA[35] and provided the impetus for many hearings[36] and studies.[37] And despite the fact that knowledgeable, responsible officials maintained that NEPA did not compel the results—bloated documentation, delays, and excessive costs—about which so many complaints were then being lodged,[38] environmental impact statements nevertheless continued generally through the mid- to late-1970s to delay agency decisionmaking in part by presenting "mammoth discourses on every conceivable environmental effect. . . ."[39]

In all the early hearings, studies, and reports on NEPA, a fair amount of agreement existed concerning both the problems with implementation of the act and the solution. Environmental impact statement preparation was placing strains on the administrative system "due to increased friction from more inputs and participants, the pressure of available environmental expertise, the awkward coordination of NEPA with the Endangered Species and Historic and Archaeological [sic] Preservation Acts, the court-prompted identification of all conceivable impacts, and, often mentioned but less important, the problems of budgeting the time and money for the EIS process."[40]

Figure 5-1.—Efforts of the Federal Aviation Administration to incorporate Section 102 of NEPA into decisionmaking for the Airport Development Aid Program, 1972.


Decisions
Decisionmaking Process
EIS Process
FAA decision to include airport development action in NASP
Sponsor decision to undertake project
Sponsor prepares initial project proposal
Sponsor obtains A-95 clearinghouse approval for submission of request
Sponsor provides opportunity for public hearing for selected airport projects
Sponsor holds hearing for selected airport projects if requested
Sponsor prepares request for aid
Sponsor submits request for aid to FAA district office
D.O. evaluates aid request
Sponsor prepares preliminary EIS
Sponsor submits preliminary EIS to state or regional clearinghouses for coordination with state and local agencies
Clearinghouses obtain state and local agency comments
Sponsor prepares draft EIS incorporating and discussing state and local agency comments and public comments if received
Sponsor submits draft EIS to FAA district office
D.O. evaluates draft EIS
D.O. recommends for or against project programming
D.O. sends aid request to regional office for review and processing
R.O. evaluates request for aid
Request for aid may be altered as a result of information obtained from internal review or from coordination of EIS
D.O. sends draft EIS to regional office for review and processing
R.O. evaluates draft EIS
R.O. furnishes federal agencies, FAA-Washington, and CEQ with draft EIS for review and comment
R.O. obtains comments from above, incorporates and discusses comments in EIS & prepares final test EIS
R.O. disapproves or recommends project for approval
R.O. sends aid request to FAA-Washington for review and processing
FAA-Washington evaluates request for aid
Request may be altered due to internal review or review of EIS
R.O. sends final EIS to FAA-Washington for review and processing
FAA-Washington evaluates final EIS. Final EIS also made available to TEU, Sec. of Trans., and CEQ
TEU or Sec. of Trans. makes final endorsement of EIS indicating final approval of environmental aspects of projects
Final endorsed EIS is incorporated with project request
Airports service makes final project evaluation & recommends project for approval
Project receives final approval by administrator of FAA or Sec. of Trans. if controversial

Source: General Accounting Office, *Report to the Subcommittee on Fisheries and Wildlife Conservation of the House Committee on Merchant Marine and Fisheries, Improvements Needed in Federal Efforts to Implement the National Environmental Policy Act of 1969,* Appendix II, page 88, (May 1972).

The purpose of the impact statement—to aid federal officials and the public in making basic policy choices—had been obscured by a blizzard of data, the compilation of which served little or no useful purpose, being motivated more often than not "by a desire to avoid or survive court review [rather] than by a felt need to balance rationally the various factors of the decision."[41]

Despite widespread criticism of NEPA, however, relatively few officials and commentators believed that the act and its special procedures did not contribute positively to agency decisionmaking. On the contrary, "NEPA . . . largely due to the implementation of section 102(2)(C), the environmental impact statement requirement," was viewed by congressional oversight committees as having been responsible for "the gain in environmental information available to the Federal Government and the public . . . [and] increasing the public ability to respond to proposed actions and to recognize their relationships to public interest. . . ."[42] Nor was NEPA, which had "borne the brunt of criticism of environmental legislation in general,"[43] really to blame. But, as is often the case with a new social force, its shortcomings, as opposed to its benefits, attracted the greatest amount of attention.

The solution to problems associated with implementation of the NEPA procedures, according to many of the same sources that targeted those problems, revolved around a single concept—integration. Thus, in responding to a request for evaluation of time delays, costs, and other effects of environmental impact statement preparation on public works projects, the Comptroller General of the United States reported:

> *When EIS preparation is integrated with and completed during project planning, it helps ensure that environmental amenities and values are given appropriate consideration along with the economic and technical factors in planning and decisionmaking. At the same time, it reduces the risk of project delays due to lawsuits, public pressure, or other circumstances which can stop projects when a timely EIS has not been prepared.*[44]

Integration as a means of overcoming the procedural problems encountered with NEPA had been supported by congressional oversight committees[45] and by CEQ, whose guidelines specified "that agencies should prepare their draft EIS as early as possible in their planning and decisionmaking process."[46] But prior to 1978 the concept of integration had not been fully developed for practical application, nor had any elements of it ever been authoritatively set forth. This was to change, however, with the promulgation of Executive Order No. 11991 of May 25, 1977,[47] directing CEQ to issue regulations intended to make the impact statement process more efficient and more useful to federal decisionmakers and the public. CEQ responded to that directive by introducing in its new regulations the concept of "total integration," providing federal agencies with uniform, practical procedures and the flexibility to adapt them to their particular programs.

Prescription for Total Integration

By the late-1970s environmental review requirements applicable to federal agency activities had proliferated considerably. The EIS component had been singled out as the principal contributor to administrative delay. But the environmental process was burdened not only by the sheer number of environmental review law requirements, but also by the multidimensional characteristics of those laws—their tendency to overlap substantively, procedurally, and even across jurisdictions. The one-dimensional, add-on approach to fulfilling the requirements of NEPA that typified federal agency compliance efforts to that point was unworkable. Agencies urgently needed a more dynamic process, one that could accommodate—or consolidate—all environmental review responsibilities.

A Planning Instrument

The CEQ regulations, which with one change[48] remain in force today, were designed specifically to address the dilemma that had been posed by misdirected agency implementation of environmental procedures in two ways. First, they establish for the "NEPA process" (defined as "all measures necessary for compliance with the requirements of section 2 and Title I of NEPA"[49]) reasonable quantitative and qualitative targets. For example, with respect to "[t]he text of final environmental impact statements," the regulations provide that it "shall normally be less than 150 pages"[50] and that the impact statements themselves "shall be analytic rather than encyclopedic."[51] But the establishment of page limits could not assure their attainment. CEQ therefore incorporated into its regulations a system of procedures that can be adapted to the decisionmaking practices of any agency for the purpose of integrating environmental considerations meaningfully and efficiently into its more mission-oriented activities. That system relies upon the three features that distinguish effective planning—timing, coordination, and scope of review—all of which are essential to achieve integration under the act.

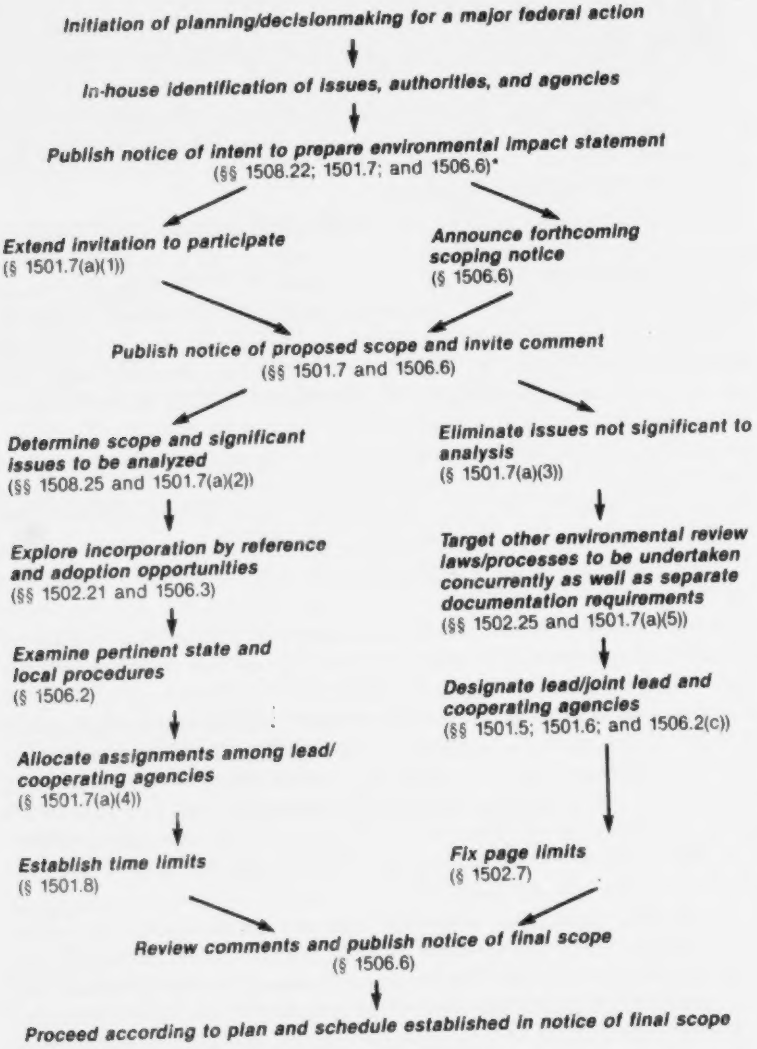
The procedural cornerstone of an effective NEPA process is timing. If agencies integrate the NEPA process into their decisionmaking at a stage where choices among alternative courses of action have been foreclosed, then it would matter little how well they analyze the effects of a proposal in a "detailed statement"; little or no real opportunity to influence the outcome from the standpoint of environmental quality remains at that stage. For this reason, the CEQ regulations require that agencies "integrate the NEPA process with other planning at the earliest possible time to insure that planning and decisions reflect environmental values, to avoid delays later in the process, and to head off potential conflicts."[52] Each federal agency is directed to "commence preparation of an environmental impact statement as close as possible to the time the agency is developing or is presented with a proposal . . . so that preparation can be completed in time for the final statement to be included in any recommendation or report on the proposal."[53] But applying the NEPA process early in agency planning and decisionmaking achieves more than just timely completion of environmental documentation; it also makes that documentation more meaningful by promoting a more fully coordinated, focused effort on the part of all concerned governmental entities and the public.

NEPA, the most comprehensive of all environmental review laws, provides a procedural canopy beneath which the act's requirements must be integrated "with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively."[54] And consistent with Congress' declaration of national environmental policy, the CEQ regulations also provide that federal agencies "shall cooperate with State and local agencies to the fullest extent possible to reduce duplication between NEPA and State and local requirements"[55] and shall "[e]ncourage and facilitate public involvement in decisions which affect the quality of the human environment."[56] The early identification of pertinent authorities and agencies potentially interested in a proposed action helps structure the public "scoping process" that brings into play the other two planning features (coordination and scope of review) to frame the essentials of environmental impact statement development—from the significant issues that must be studied and the scheduling of document preparation to designation of agencies that will cooperate in the study and the nature and extent of their participation.[57] The use of other integrative procedures prescribed in the CEQ regulations, including incorporation of material by reference[58] and adoption of previously prepared environmental documentation,[59] should also be explored during the "scoping process." Upon completion of that process, government agencies, the public, and other interests will find themselves equipped with a flexible blueprint for fully integrating a concise, predictable, analytical environmental process into agency decisionmaking before work on the actual environmental impact statement is even begun.

Where and How to Integrate

In its simplest form and reduced to a schematic, the pivotal pre-EIS phase of the NEPA process for a "major federal action" might resemble the diagram in Figure 5-2.

Figure 5-2.—Planning for integration of environmental laws.


Initiation of planning/decisionmaking for a major federal action
In-house identification of issues, authorities, and agencies
Publish notice of intent to prepare environmental impact statement (§§ 1508.22; 1501.7; and 1506.6)*
Extend invitation to participate (§ 1501.7(a)(1))
Announce forthcoming scoping notice (§ 1506.6)
Publish notice of proposed scope and invite comment (§§ 1501.7 and 1506.6)
Determine scope and significant issues to be analyzed (§§ 1508.25 and 1501.7(a)(2))
Explore incorporation by reference and adoption opportunities (§§ 1502.21 and 1506.3)
Examine pertinent state and local procedures (§ 1506.2)
Allocate assignments among lead/cooperating agencies (§ 1501.7(a)(4))
Establish time limits (§ 1501.8)
Eliminate issues not significant to analysis (§ 1501.7(a)(3))
Target other environmental review laws/processes to be undertaken concurrently as well as separate documentation requirements (§§ 1502.25 and 1501.7(a)(5))
Designate lead/joint lead and cooperating agencies (§§ 1501.5; 1501.6; and 1506.2(c))
Fix page limits (§ 1502.7)
Review comments and publish notice of final scope (§ 1506.6)
Proceed according to plan and schedule established in notice of final scope

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* Section Citations, Title 40 of the Code of Federal Regulations.

Source: CEQ.

Of course, comparatively few major federal actions are uncomplicated for purposes of NEPA and other environmental review laws. This is particularly true of major federal actions that originate as proposals sponsored by nonfederal grant or license applicants. The difficulty with applicant-sponsored proposals is that the federal approval stage generally represents one of the final steps in a planning process that often began months, and even years, before. But the CEQ regulations address this situation as well, essentially by requiring integration of environmental factors and alternatives into the prefiling planning processes of prospective applicants.

Under the CEQ regulations, federal agencies must "[p]rovide for cases where actions are planned by private applicants or other non-Federal entities before Federal involvement. . . ."[60] In designing procedures to assist applicants sponsoring proposals for federal approval, agencies should include an "outreach program," such as a means for prospective applicants to conduct pre-application consultations with the lead and cooperating agencies. Applicants need to find out, in advance of project planning, what environmental studies or other information will be required, and what mitigation requirements are likely, in connection with the later federal NEPA process. Agencies should designate staff to advise potential applicants of the agency's NEPA information requirements and should publicize their pre-application procedures and information requirements in newsletters or other media used by potential applicants.[61]

Agencies also must provide assistance for prospective applicants by outlining data requirements where environmental reports and other material are submitted with an application.[62] Finally, to hasten the processing of applicant-sponsored proposals and to eliminate duplication of effort, the CEQ regulations permit applicants to prepare for their proposed actions environmental assessments that are subject to independent review and verification by the agency[63] or, in cases where environmental impact statements are required, to have the draft impact statement prepared in advance of application filing pursuant to a third-party contract arrangement.[64]

The CEQ regulations anticipate and provide for most of the situations that might be encountered in applying the NEPA process to federal actions. Still, stumbling blocks are almost always present. One such stumbling block involves situations in which applicant-sponsored proposals are subject to multiple permitting or review requirements (such as permitting by the Army Corps of Engineers under section 404 of the Clean Water Act or review pursuant to section 106 of the National Historic Preservation Act). The CEQ regulations call for "[o]ther federal agencies that are likely to become involved . . . [to] be contacted, and the NEPA process coordinated, to insure an early and comprehensive analysis of the direct and indirect effects of the proposal and any related actions."[65]

But other federal agencies generally have their own workload and scheduling demands from which they may be reluctant to depart on a case-by-case basis, regardless of how early they may be invited to participate in the decisionmaking process of the lead federal agency. An alternative approach in these types of situations, where recurrent filings are expected, is execution of a programmatic memorandum of agreement[66] between or among multiple permitting agencies to establish mutually acceptable consolidated review procedures applicable to all similar applicant-sponsored filings.

Integration in Practice

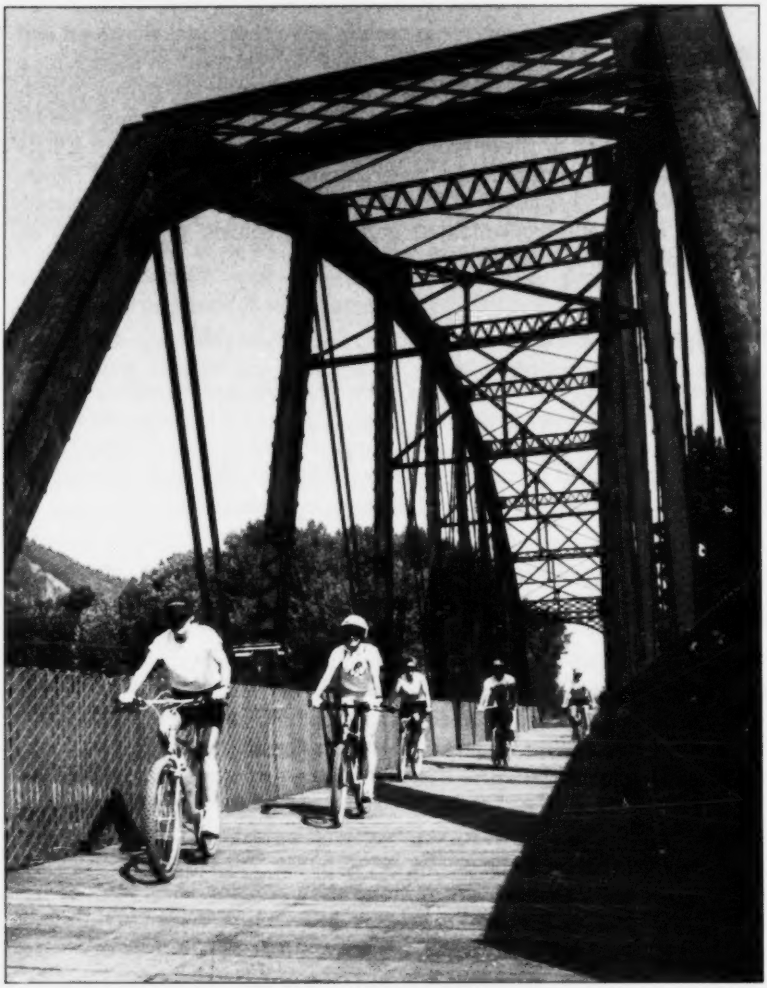
Neither the provisions of NEPA nor the CEQ implementing regulations function as stand-alone mandates. The NEPA process can be understood only in the context of a statutory scheme and program to which it applies. But integration of the NEPA process is not always easily achieved, as evidenced in the following case studies.

Interstate Commerce Commission: Railroad Abandonment

Abandonment of railroad lines involves a statutory scheme that is somewhat inhospitable to, although clearly within the ambit of,[67] the NEPA process. Railroad abandonment applications, submitted for approval to the Interstate Commerce Commission (ICC), are sponsored by abandoning rail carriers and involve alternatives that require the initiative of outside entities. Additionally, the entire rail abandonment application process is subject to adjudicative (trial-type) procedures and stringent statutory deadlines. In all, a better opportunity to demonstrate the versatility of NEPA in integrating environmental considerations into agency decisionmaking—especially adjudications—is difficult to imagine.

Impacts

Railroad abandonment generally occurs after the quantity of freight available to a rail carrier over a particular line has diminished to the point that continued operations are economically infeasible and the operator determines that its opportunity costs—"the real economic loss an entity experiences when it must forego some other, more profitable use of its resources"[68]—require liquidation of wasting assets, including track, ties, appurtenances, and real estate. Most likely candidates for abandonment are light density branch lines, viewed by Congress as "the most economically exposed part of the rail system and most vulnerable to competition from other modes."[69]



Rails-to-Trails Conservancy

Abandoned railroad rights-of-way can serve as an adjunct to the national trails system.

Abandonment is a statutory option available to the railroad industry so that it will "not be forced to continue to internalize all losses from branch line operations, thereby further jeopardizing the industry's already precarious economic health."[70] In providing the abandonment option to railroads, Congress was not insensitive to the needs of shippers who rely on railroad service or to state government programs and local communities.[71] To satisfy concern for the rail system's ability to meet unforeseen future transportation demands[72] and the current needs of shippers, state and local governments, and the public, Congress enacted several statutory alternatives to railroad abandonment.

Railroad abandonment also has great potential to affect the quality of the human environment. Principal impact-producing phenomena, all of which occur following abandonment authorization by ICC, include diversion of rail traffic over active lines to other transportation modes—primarily truck; salvage of track, ties, bridges, and other appurtenances; and disposal of the right-of-way, normally through sale or reversion.[73] Aspects of environmental quality that may be affected by railroad abandonment are as varied as the terrain crossed by the railroad and include prime and unique farmlands, wetlands and water quality, historic and cultural resources, endangered species and habitat, as well as energy efficiency, air quality, and transportation safety. Abandonments, therefore, are often subject to multiple permitting and environmental review requirements.

Statutory Alternatives

Foremost among statutory alternatives to railroad abandonment are provisions of the Interstate Commerce Act (ICA),[74] under which any financially responsible person may offer to subsidize or acquire for continued operations a line of railroad approved by ICC for abandonment. The offer must be submitted within ten days of notice in the Federal Register that an abandonment has been approved.[75] If ICC finds that the offer meets certain minimum requirements, issuance of abandonment certification is postponed to allow the parties time to negotiate an agreement.[76] If agreement is reached or if, upon request of either party, ICC establishes acceptable terms and conditions,[77] then the line is not abandoned. This provision contemplates a forced sale or subsidy to continue railroad operations over the line.[78]

Section 8(d) of the National Trails System Act was amended by Congress in 1983[79] to achieve a twofold purpose. First, the amendment seeks to put aside or bank for future reactivation transportation corridors of presently unproductive rail lines approved for abandonment. "Rail banking" is consistent with "the National policy to preserve established railroad rights-of-way for future reactivation of rail service, to protect rail transportation corridors, and to encourage energy-efficient transportation use."[80] Second, the amendment provides that any such corridor not remain idly preserved awaiting future reactivation but that it be employed as an adjunct to the system of national trails for recreational purposes. A state, political subdivision, or qualified private organization willing to assume responsibility for trails management, legal liability, and taxes may attempt to invoke the provisions of section 8(d). If the abandoning railroad consents, ICC will issue an instrument that allows the parties 180 days in which to negotiate transfer of the right-of-way for trails use and will not permit abandonment inconsistent or disruptive of interim trails use.[81] This statutory scheme safeguards the linear integrity of the right-of-way, preventing reversionary interests, if any, from taking effect[82] while permitting the railroad to achieve its objective—discontinuing service over an otherwise unprofitable line and salvaging track, ties, and other appurtenances not necessary to support a recreational trail.[83]

Finally, ICA provides an alternative to abandonment that would not necessarily lead to continued railroad operations but would encourage more effective public use of abandoned rights-of-way. Congress found such rights-of-way "constitute a unique resource," the future public use of which is a necessary consideration in abandonment proceedings.[84] Accordingly, ICC determines for each abandonment proposal whether rail properties are suitable for use for public purposes, including highways, other forms of mass transportation, conservation, energy production or transmission, or recreation. If the Commission finds that the rail properties proposed to be abandoned are suitable for public purposes, the properties may be sold, leased, exchanged, or otherwise disposed of only under conditions provided in the order of the Commission.[85]

The condition ICC customarily imposes on abandonment authorizations, but only upon substantiated request, prohibits a railroad from disposing of its property for a period of up to 180 days unless the properties are first offered, on reasonable terms, for sale for public purposes.[86] A condition to this effect provides a negotiating preference but has never been interpreted to require a railroad to enter into negotiations.[87]

In providing statutory alternatives to abandonment that could result in continued rail service, Congress has not let social and economic concerns overshadow environmental policy objectives. On the contrary, Congress has always viewed rail service and rail transportation as offering "economic and environmental advantages with respect to land use, air pollution, noise levels, energy efficiency and conservation, resource allocation, safety, and cost per ton-mile of movement to such extent that the preservation and maintenance of adequate and efficient rail service is in the national interest."[88] At the same time, however, ICA's abandonment procedures—especially the time constraints that govern application processing—do not make it very easy for affected interests or the public to avail themselves of statutory alternatives to abandonment.

Interstate Commerce Act Procedures

NEPA *supplements* existing agency authorizations. Any attempt to integrate in a meaningful way consideration of environmental factors and alternatives into agency decisionmaking requires that agency authorizations first be examined very closely.

- **ICA Prefiling Requirements**. For prospective purchasers of about-to-be abandoned railroad lines, whether by lease or purchase for continued operations, "banking," or public use, the preliminary work—feasibility study preparation, securing necessary capital, shipper backing, and the like—can be quite costly and time-consuming.[89] For this reason, railroads have been required by statute since 1976 to maintain and update complete diagrams of their operating systems that must "include a detailed description of each of its railroad lines potentially subject to abandonment; and . . . identify each railroad line for which the carrier plans to file an application for a certificate [of abandonment]. . . ."[90] ICC is prohibited from granting an application for railroad abandonment that is opposed by a shipper or significant user of the line or a state or political subdivision in which any part of the line is located until "the railroad line has been described and identified in the diagram or amendment to the diagram of the rail carrier that was submitted to the Commission at least 4 months before the date on which the application was filed."[91] But just because a rail line is listed in a system diagram as potentially subject to abandonment does not mean that an application is imminent or must be filed at all.

Immediately before filing an abandonment application with ICC, a carrier must provide advance public notice. The "notice of intent" must describe the abandonment for which the carrier will apply, supply reasons for seeking abandonment, and advise interested persons of their right to participate.[92] The notice must also include (i) a statement that the line is available for subsidy or sale in accordance with section 10905 of this title, (ii) a statement that the carrier will promptly provide to each interested party an estimate of the subsidy and minimum purchase price required to keep the line in operation . . . and (iii) the name and business address of the person who is authorized to discuss sale or subsidy terms for the carrier.[93]

The carrier is further required to send a copy of its notice to the governor of any state directly affected; to post a copy of the notice in each terminal and station on the line; to publish the notice for three consecutive weeks in newspapers of general circulation in each county where the line is located; and to mail a copy of the notice to all shippers that made significant use of the line in the preceding 12 months.[94]

- **ICA Application Procedures**. To facilitate the rail transportation policy's objective of requiring "fair and expeditious regulatory decisions when regulation is required,"[95] ICA provides for accelerated processing of railroad abandonment applications. If protests to an application are not filed within 30 days, a decision to grant the application is required within 45 days after the application is filed.[96] If protests are filed in a timely manner, a decision whether or not to investigate the matter is required within that same time period.[97] Further proceedings would follow a decision to investigate, whereas a

> decision not to investigate would require a decision on the merits within 75 days after the application is filed.[98] No circumstance would compel investigation of any abandonment application.[99]

Statutory Conflicts Dilemma

ICA time constraints on the processing of railroad abandonment applications impinge on the ability of ICC to fulfill the requirements of applicable environmental review laws. The forty-fifth day after an abandonment application is filed—the day on which the first decision under the ICA must be made—is crucial for purposes of the NEPA process, which requires that substantive decisions (here the granting of abandonment) be made only after the agency has taken a "hard look" at environmental factors.[100] To accommodate this requirement, environmental documentation must be completed and submitted to the decisionmaker well in advance of the forty-fifth day after an abandonment application is filed. Protests to an abandonment application, which would provide slightly more time for completing the NEPA process, generally are not submitted in advance of the thirtieth day after an application has been filed and cannot be counted on to provide additional processing time. For these reasons, environmental documentation prepared for abandonment applications is normally made available to the ICC decisionmaker within 33 calendar days of application filing.

The environmental effects of most proposed railroad abandonments, some of which may extend 200 miles or more,[101] could not possibly be completely evaluated by ICC in a month's time. The section 106 National Historic Preservation Act process, which is almost always involved in railroad abandonments, may itself take much longer than a month to complete.[102] Add to that required considerations under other federal statutes often involved in railroad abandonments, including section 7 of the Endangered Species Act, the Clean Water Act, the Coastal Zone Management Act, and many, many more, as well as state and local requirements that frequently come into play, and the tremendous demands of the environmental process on the ICC rail abandonment licensing function become readily apparent. To cope with those demands and at the same time fulfill the rail transportation policy's requirement for fair and expeditious decisionmaking, ICC has sought to integrate all environmental considerations into the prefiling planning processes of prospective applicants.

Under ICC environmental procedures, an "environmental report" addressing more than a dozen areas of environmental concern normally associated with railroad abandonments must accompany application filings.[103] In meeting those environmental reporting requirements, prospective applicants must calculate the impact of proposed abandonments on the affected natural, physical, social, and economic environment. ICC procedures also require carriers to undertake extensive prefiling consultations with federal, state, and local officials and planners for the purpose of ascertaining in advance of filing what other permitting (such as Corps of Engineers under section 404 of the Clean Water Act) or review requirements (such as cultural resource surveys under section 106 of the National Historic Preservation Act) may apply and to begin satisfying those requirements so that *all* permitting and review functions can be completed simultaneously. But the ICC does not expect or require prospective applicants to fend for themselves in fulfilling reporting or consultation requirements; instead, "[i]nformation . . . and other forms of assistance [are] made available upon request" to rail applicants and others under the agency's environmental procedures.[104]

ICC has attempted to further offset limiting provisions of ICA where that act provides "some latitude to set timeframes for the filing of pleadings."[105] Thus, ICC *requires* prospective applicants for railroad abandonment to submit historic resource data to responsible state officials at the same time that they file their notice of intent to "assure the Commission the maximum time to make the appropriate determinations."[106] In establishing this requirement, ICC noted "that the early submission of historical data may ultimately speed the processing of some proceedings by encouraging the earliest resolution of environmental matters. While some applicants may be required to alter their current data collection practices, the benefits of this proposal outweigh this minor detriment to carriers."[107] A programmatic memorandum of agreement, designed to tailor the section 106 National Historic Preservation Act requirements to railroad abandonment proceedings under ICA, was also negotiated by ICC in 1987 but never signed.[108]

The notice of intent, an early-warning device second only to the system diagram requirements, is the vehicle that ICC has settled on, insofar as rail abandonment application proceedings are concerned, to invigorate the NEPA process. Statutory notice of intent requirements, which contemplate widespread advance public notice, have been enlarged by ICC to embrace every alternative to abandonment as well as other environmental concerns. ICC procedures invite would-be participants specifically to address, in protests to or comments on abandonment applications, issues that include the following:

- Any intent to offer financial assistance for continued operations;
- Environmental effects;
- Impacts on rural and community development;
- Suitability of rail properties for other public purposes; and
- Prospective use of rights-of-way for interim trail use and rail banking.[109]

Comments submitted in response to a carrier's notice of intent, together with the environmental report that must accompany the abandonment application and any additional data gathered by ICC, form the database for environmental evaluation.

ICC environmental procedures classify railroad abandonments for NEPA purposes as actions normally requiring preparation of an environmental assessment.[110] Although, consistent with CEQ regulations, railroad applicants could be allowed to submit environmental assessments with their applications,[111] that approach to document preparation is not reflected in ICC procedures, apparently because the agency has found that it can efficiently prepare concise environmental assessments (well within the 10- to 15-page limit prescribed by CEQ[112]) while reviewing and verifying data contained in environmental reports. Whether the statutory scheme for rail abandonment applications can accommodate the EIS process depends on a number of factors,[113] although ICC recently prepared an environmental impact statement for a ten-mile rail abandonment in the metropolitan Washington, D.C., area.[114] But the demands of the environmental assessment process for railroad abandonment applications offer more than sufficient challenge, especially with respect to consideration of alternatives.

Considering Alternatives

Every environmental assessment must "include brief discussions of the need for the proposal, of alternatives as required by sec. 102(2)(E), of the environmental impacts of the proposed action and alternatives, along with a listing of agencies and persons consulted."[115] Consideration of alternatives, which is viewed as the heart of the NEPA process,[116] requires rigorous exploration and objective evaluation of all reasonable alternatives to a proposed action,[117] particularly those that would avoid or mitigate adverse environmental effects.[118] This requirement assures "that alternatives are explored in the initial decision-making process and to provide an opportunity to those removed from that process also to evaluate the alternatives."[119]

In targeting available alternatives for evaluation, an agency may not focus exclusively on the limited objectives of an applicant for a federal license, nor may the agency consider only those alternatives that are within its jurisdiction or power to bring about.[120] Instead, "NEPA case law on this issue requires consideration of both public and private purpose and need. The agency may properly focus its evaluation of alternatives based upon the applicant's goals, but it must also exercise independent judgment regarding the appropriate articulation of the objective purpose and need and the reasonableness of various alternatives."[121]

Broad-based agency evaluation of alternatives to railroad abandonment is consistent with the public interest. For these valuable and unique resources, Congress specifically has provided several alternatives, each of which promotes the rail transportation policy. Since these alternatives generally contribute to the maintenance and enhancement of environmental quality, the objectives of NEPA and ICA in this regard are mutually reinforcing. Seldom, however, will an environmental assessment prepared for an abandonment application contain an "evaluation" of alternatives. But evaluation of alternatives to railroad abandonment may not be as important as providing notice of their availability.

Statutory alternatives to abandonment are not within the discretion of either ICC or the abandoning rail carrier to effectuate, a fact which by itself would not necessarily excuse a failure to consider such alternatives.[122] But here ICC is not in a position, prior to any concrete expression of interest—or a "proposal" as that term is understood for NEPA purposes[123]—to evaluate an alternative's feasibility or likelihood of success at the state or local level where, according to Congress, "responsibility [belongs] for making the decisions on the essentiality of . . . rail service. . . ."[124] Short of undertaking a programmatic examination of the nation's rail transportation system for the purpose of anticipating long-term needs and opportunities, ICC can do little more than it has done in individual abandonment application proceedings to further pursuit of alternatives: namely, to integrate notice of their availability into the prefiling requirements of abandoning rail carriers and to provide a process for reviewing subsequent negotiated transfers of rights-of-way. If a state, political subdivision, or an interested person expresses interest in pursuing one or more of the statutory alternatives, ICC will be aware of that interest before resources are irretrievably committed and will order follow-up proceedings consistent with the statute.

The carefully constructed ICC environmental review system for rail abandonment applications has proven itself on many occasions. A 1985-1986 abandonment application proceeding involving a segment of the Boston and Maine Railroad's Hillsboro Branch in Bennington, New Hampshire, will serve briefly to illustrate the point. The rail line proposed for abandonment in that proceeding provided service to the Monadnock Paper Mills, the operations of which dated to 1819, making it the oldest continuously operating paper mill in the country.[125] Not only was the line's principal customer a historical landmark, eligible for listing in the National Register, but it was also the nucleus of commercial and social life in Bennington for nearly two centuries.

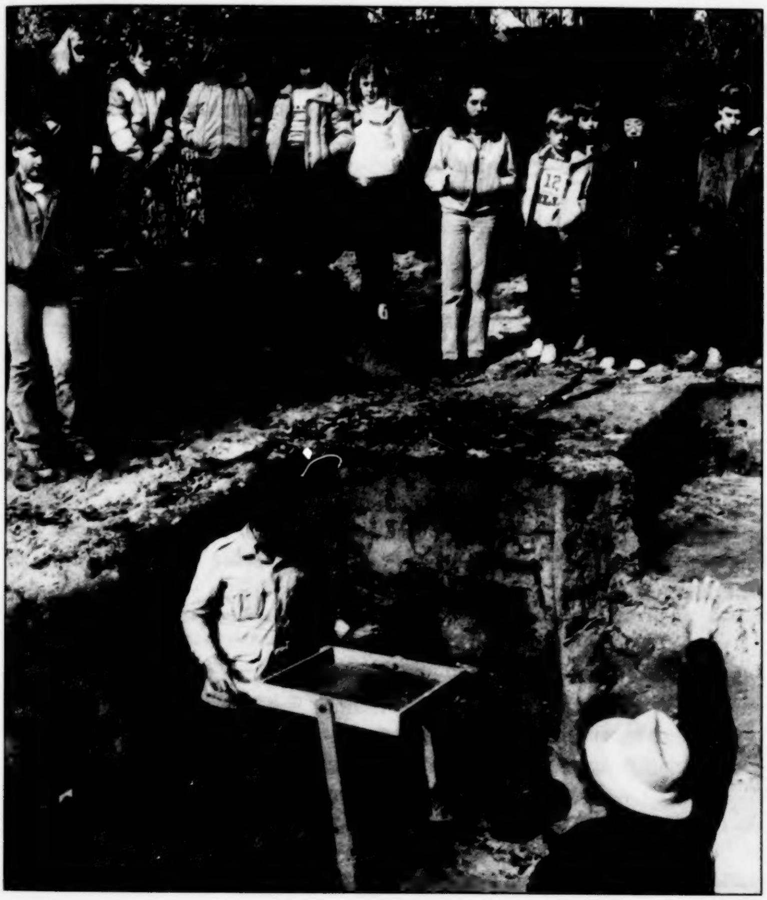
ICC was alerted to the paper mill's historical significance and its importance to the local economy by John Flanders, New Hampshire's historic preservation officer, who had received the railroad's notice of intent containing historic resource data, a description of available alternatives to keep the line in operation, and other pertinent information

CASE STUDY

NEPA: Preserving the Nation's Cultural Heritage

Although an objective of NEPA is to "preserve important historic, cultural, and natural aspects of our national heritage,"[137] the effects of federal agency decisionmaking "on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register,"[138] must also be considered under section 106 of the National Historic Preservation Act (NHPA).[139] Implementing regulations of the Advisory Council on Historic Preservation develop what is known as the section 106 process, under which effects of federal decisionmaking on resources included in or eligible for inclusion in the National Register are taken into account.[140] And while the "judgments of historical significance made by the Advisory Council on Historic Preservation, the expert regulatory body concerned with preserving, restoring, and maintaining the historic and cultural environment of the Nation . . . deserve great weight . . . compliance with the NHPA, even when it exists, does not assure compliance with NEPA. Each mandates separate and distinct procedures, both of which must be complied with when historic buildings are affected."[141] Even the "[e]xecution of a 'Memorandum of Agreement' with the Advisory Council on Historic Preservation . . . does not relieve a federal agency of the duty of complying with the impact statement requirement 'to the fullest extent possible,' 42 U.S.C. § 4332."[142] But "[c]urrent regulations envision [and encourage] that both [NEPA and NHPA] may be applied simultaneously, and provide procedures by which a single document may often satisfy an agency's responsibilities under both [statutes]. *See* 36 C.F.R. § 800.9 [1990]; 40 C.F.R. §§ 1502.25, 1506.4 [1990]."[143]

weeks before the application was actually filed.[126] Timely notification of the planned abandonment and opportunity to comment resulted in preparation of a cultural resource survey that ICC was able to complete prior to the statutory deadline for decision on the application. Because the survey determined that the abandonment's principle adverse effect on the historical integrity of the mill complex could be avoided only through continued operation of the railroad, all statutory alternatives for continuing rail service to the mill or "banking" the line for future reactivation were fully explored.[127] Although abandonment of the rail line ultimately was authorized by the ICC because no entity cared to acquire, operate, or "bank" the line, the interest generated by the environmental process induced the railroad to keep the line intact. Recently, proposals to reinstitute service over the line to the historic mill complex have surfaced and are now being actively considered.[128]



Advisory Council on Historic Preservation

A field trip to an archeological dig demonstrates the benefits of integrating environmental concerns into land-use planning (see case study facing page).

The environmental process that ICC painstakingly fashioned for abandonment applications was not extended to include the other, larger (now accounting for the majority of rail line abandonments[129]) component of the rail abandonment program that involves so-called "exempt" transactions. Exempt abandonment transactions, which are not subject to the stringent statutory time constraints that govern abandonment applications,[130] must also comply with the requirements of NEPA and other environmental review laws.[131] But widespread advance public notice of such exemptions and of statutory alternatives to abandonment is not effectively provided,[132] nor is environmental documentation prepared prior to exemption approval.[133] As a consequence a genuine opportunity to promote environmental and rail transportation policies may be missing from a substantial number of abandonments.[134] And although the disjointed, add-on environmental process that ICC adopted for exempt rail abandonments has been sanctioned by one federal appeals court,[135] not all intended beneficiaries of statutory alternatives to abandonment are entirely satisfied with the outcome. The National League of Cities has called on Congress

> *. . . to require a railroad to notify elected officials and local citizens of all abandonments, including exempt abandonments, in sufficient time for local officials and citizens to exercise all remedies before the ICC to preserve a rail corridor for alternative public uses, including recreation, public transit and utility corridor. Currently, ICC and railroads provide essentially no notice in half or more of rail abandonment proceedings. A minimum of eight weeks should be required.*[136]

The policies, statutes, and procedures that govern or affect railroad abandonment applications demonstrate the complexities involved in integrating environmental considerations into agency decisionmaking, especially when that decisionmaking is accomplished by means of adjudication. NEPA, however,

> *. . . was not intended to accommodate conventional licensing and regulatory procedures. It was not intended to draw nice distinctions between agency discretion and the public concern for the environment. It was intended to modify fundamentally the basis of . . . decisionmaking on matters affecting the quality of the environment; legal technicalities of agency procedure were to accommodate its policy objectives—not vice versa.*[137]

That accommodation is seldom easy. And as the number and scope of authorities that apply to agency decisionmaking increase, the difficulty in accommodating the objectives of NEPA increases proportionately. But the CEQ regulations, purposefully applied, will overcome that difficulty and promote effective, efficient integration of environmental considerations into agency decisionmaking.

Minerals Management Service: Outer Continental Shelf Lease Sales

The Outer Continental Shelf (OCS) oil and gas lease sale program offers a contrasting study with respect to integration of environmental factors into agency decisionmaking, one in which an extremely complex planning process is combined with the potential for uncertainty regarding environmental effects.

Challenges of the OCS Lease Sale Program

In many respects, the OCS program represents the ultimate challenge to policy integration. The setting of policy conflict was described succinctly in a 1977 congressional report on proposed amendments to the Outer Continental Shelf Leasing Act (OCSLA):

> *If the Santa Barbara oil spill raised the level of environmental consciousness about OCS operations, the shortfall of domestic energy production and the Arab oil embargo of 1973 had an equally dramatic impact. The potential oil and gas resources on the OCS could reduce the country's dependence on foreign energy supplies and thus its economic vulnerability in relation to the OPEC nations. Both trains of thought—environmental protection and the acceleration of OCS oil and gas development—competed for primary ranking in the list of national priorities.*[145]

Resolution of this policy conflict, which continues in large measure today, is achieved under OCSLA by means of a multistage developmental program that "is to be balanced, considering all economic, social, and environmental impacts of oil and gas activities."[146]

Congressional concern for the effects of OCS oil and gas development on the quality of the human environment is evident throughout OCSLA, which was amended extensively in 1978 "to promote the swift, orderly and efficient exploitation of our almost untapped domestic oil and gas resources in the Outer Continental Shelf."[147] In OCSLA, Congress has provided that "the whole OCS process, from preparation of a leasing program, selection of tracts for leasing, promulgation and enforcement of regulations, and review of activities must consider environmental consequences."[148] Specific reference is also made in OCSLA to NEPA.[149] OCSLA "does not limit NEPA's basic application, *see* 43 U.S.C. § 1866; instead, the two statutory schemes are complementary. . . . At the lease sale stage, OCSLA implies [that the Secretary's] review must meet NEPA standards. *See* 43 U.S.C. § 1346(a)(1) ('The Secretary shall conduct a study . . . in order to establish information needed for assessment and management of environmental impacts. . . .')."[150]

Congress was concerned not only with effects of the OCS program on the environment but also that decisions concerning domestic energy production not be *needlessly* delayed by environmental considerations. To "[a]llow the [OCS] resources to become available for domestic use as rapidly as possible,"[151] Congress included several key provisions in the 1978 amendments to OCSLA. First, it divided the OCS program into four statutory stages, each of which "involves separate regulatory [including environmental] review that may, but need not, conclude in the transfer to lease purchasers of rights to conduct additional activities on the OCS."[152] Second, environmental studies were directed to be undertaken well in advance ("not later than six months prior to the holding of a lease sale"[153]) of decisionmaking. Finally, the Secretary was permitted in developing environmental studies to support his OCS decisionmaking to use information derived from other federal studies, including environmental impact statements, or from any state or local government or from any person.[154]

Many of the procedures that Congress incorporated into the 1978 amendments to OCSLA anticipated the CEQ regulations, which were then in the process of being developed. Congress was very much aware of the CEQ efforts at that time and had determined "that the NEPA impact statement process when applicable, should not unnecessarily delay [OCS decisionmaking]."[155] For this reason, Congress supported "the directive of President Carter to the Chairman of the Council on Environmental Quality, that he promulgate new guidelines designed to expedite the process."[156] But regardless of how integrated environmental review is ordained—whether by an agency's organic charter or through application of the CEQ regulations—it cannot assure that all pertinent values will be fully considered prior to decision. It may be that the full range of environmental impacts associated with a proposed action are beyond what science and technology are capable of ascertaining. The CEQ regulations cannot fill an evaluative void occasioned by missing data but they will permit decisionmaking to go forward in the face of uncertainty, even where different standards apply.

Evaluating Effects on Endangered Species

Although OCSLA makes no direct reference to the Endangered Species Act (ESA) as it does to NEPA, the provisions of ESA apply of their own force and effect to the Secretary's OCS decisionmaking.[157] Moreover, ESA applies equally to each stage of decisionmaking, including the lease sale stage.[158] Thus, before the Secretary makes any lease sale decision under OCSLA, he must ensure, consistent with section 7(a)(2) of ESA, that his action "is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species. . ."[159]

Briefly, a section 7 ESA consultation requires that the agency with jurisdiction over an endangered species—either the Fish and Wildlife Service (FWS) of the Department of Interior or the National Marine Fisheries Service (NMFS) of the Department of Commerce—must be consulted by the action agency (the Minerals Management Service (MMS) has been delegated initial decisionmaking functions under OCSLA) to determine whether any likelihood exists of jeopardizing the continued existence of an endangered species. A "biological assessment," defined as "the information prepared by or under the direction of the Federal agency concerning listed and proposed species and designated and proposed critical habitat that may be present in the action area and the evaluation [of] potential effects of the action on such species and habitat,"[160] will normally be prepared when endangered species are determined to be present in the action area. Based on that assessment and following formal consultation, if required, FWS and/or NMFS, relying on "the best scientific and commercial data available,"[161] will issue a "biological opinion," which is defined as "the document that states the opinion of the Service as to whether or not the Federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat."[162] Following issuance of the opinion, the federal action agency must "determine whether and in what manner to proceed with the action in light of its section 7 obligations and the Service's biological opinion."[163]

Consideration of OCS lease sale effects on species (whether or not endangered) and habitat under NEPA involves a much less structured inquiry. The essentially procedural requirements of NEPA are satisfied if, on balance, the administrative record, including the environmental impact statement and any accompanying consultative documents, discloses that the decisionmaker has taken a "hard look"[164] at the consequences of its proposed action on species and habitat.

> *NEPA requires that the EIS alert the decisionmaker to both the consequences of a proposal and alternatives to it, [but] the agency's responsibility under NEPA is guided by a rule of reason. The decision of how much detail to include is one for the agency itself. The discussion need not be exhaustive so long as it provides 'information sufficient to permit a reasoned choice of alternatives so far as environmental aspects are concerned.' . . . NEPA obligates an agency to seek out the environmental consequences of a proposal and consider every significant aspect of its environmental impact. . . .* [165]

Endangered species that inhabit or migrate through lease sale areas are the subject of "program studies," some extending as much as four years or more.[166] These studies are not undertaken only in response to lease sale proposals; rather, consistent with section 20 of OCSLA,[167] implementing regulations call for a continual "environmental studies program to collect information to assess and manage environmental impacts of OCS oil and gas development on human, marine, and coastal environments."[168] Study needs are identified annually, "approximately 2 years in advance of when studies are expected to begin."[169] In these circumstances, the "best scientific and commercial data" concerning effects of the OCS program on endangered species and their habitat are in a perpetual state of development. Even after "conducting these studies, and any other tests and studies which are suggested by the best available science and technology, the most informed judgment of risk of jeopardy to an endangered species will still have a large component of estimate, its quantitative element being incapable of precise verification."[170] And although uncertainties generated by "program studies" and their subject matter affect ESA and NEPA analyses similarly, standards governing decisionmaking under each statute differ somewhat, thereby complicating integration of environmental considerations.

Proceeding with Decisionmaking in the Face of Uncertainty

Section 7(d) of ESA provides that, after consultation required by section 7(a)(2) is initiated, "the Federal agency and the permit or license applicant shall not make any irreversible or irretrievable commitment of resources with respect to the agency action which has the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures which would not violate subsection (a)(2) of this section."[171] Until a biological opinion is issued by FWS and/or NMFS, the action agency, MMS, cannot proceed with its lease sale activities. It is entirely foreseeable that a biological opinion will not be able to evaluate with certainty what all the effects of a proposed action will be. This uncertainty could easily lead to decisional paralysis.

Congress, however, did not intend that the directives of ESA should be interpreted to cause program gridlock in the face of uncertainty. In the process of amending ESA in 1979, Congress made clear its intention that the act "not be interpreted to force the [Services] to issue negative biological opinions whenever the action agency cannot guarantee with certainty that the agency action will not jeopardize the continued existence of the listed species or adversely modify its critical habitat."[172] Instead, the wildlife agencies would be permitted "to frame their section 7(b) opinions on the best evidence that is available or can be developed during consultation. If the biological opinion is rendered on the basis of inadequate information, then the Federal agency has a continuing obligation to make a reasonable effort to develop that information."[173]

Special provision has also been made for consultations under section 7 of ESA on multistage projects, such as those authorized by OCSLA. Regulations implementing section 7 of ESA provide that "[w]hen the action is authorized by a statute that allows the agency to take incremental steps toward the completion of the action, the Service shall, if requested by the Federal agency, issue a biological opinion on the incremental step being considered, including its views on the entire action."[174] Upon issuance of such biological opinion, the action agency may then proceed conditionally with the incremental step. Conditions include that the incremental step itself not violate section 7(a)(2) or 7(d) of ESA; that consultation continues for the entire project and each succeeding incremental step; that the action agency continue to secure data in support of biological opinions; and that a reasonable likelihood exists that the entire project will not violate section 7(a)(2).[175]

Regulations implementing ESA accommodate the structure and demands of OCSLA in terms of fulfilling the consultation requirements of section 7 for lease sale activities that may have speculative effects on endangered species and their habitat, but they do not completely satisfy the requirements of NEPA.[176] Strict limits are placed by NEPA on actions that may be taken prior to completing the EIS process. The CEQ regulations provide that "[u]ntil an agency issues a record of decision . . . no action concerning the proposal shall be taken which would: (1) Have an adverse environmental impact; or (2) Limit the choice of reasonable alternatives."[177] Unlike ESA, however, segmentation of actions under NEPA is generally not recognized as a legitimate means of accomplishing the act's mandates.[178] The only exception to this rule involves interim action that is part of a program for which an EIS is being prepared and such action is "justified independently of the program [and is] itself accompanied by an adequate environmental impact statement,"[179] an exception for which lease sale decisions would not qualify because every significant aspect of their environmental impact on species and habitat could not be fully considered under incremental-step biological opinions.[180]

But Congress recognized in formulating a national policy for the environment that all risk to that environment could not possibly be eliminated from the decisionmaking process, that civilization has advanced by taking risks with the environment, risks that must continue to be taken despite a lack of complete foreknowledge of the consequences of many activities.[181] The CEQ regulations address the need for risk-taking when information necessary to environmentally informed decisionmaking is incomplete or unavailable and also strive to accommodate Congress' desire to provide an "early warning system" for unwanted consequences.[182] Proceeding with decisionmaking in the face of uncertainty concerning potentially significant environmental effects was the subject of a 1986 amendment to the CEQ regulations that sought to avoid "distorting the decisionmaking process by overemphasizing highly speculative harms"[183] while seeking to promote integration of analyses and data generated in pursuit of more specific environmental/scientific inquiries. That amendment, which replaced the so-called "worst-case" requirement, directs that "federal agencies, in the face of unavailable information concerning a reasonably foreseeable significant environmental consequence, prepare 'a summary of existing credible scientific evidence which is relevant to evaluating the . . . adverse impacts' and prepare an 'evaluation of such impacts based upon theoretical approaches or research methods generally accepted in the scientific community.'"[184]

In the case of lease sales for which incremental-step biological opinions have been prepared, development of an "adequate environmental impact statement" need not be postponed or even delayed appreciably. Under the CEQ regulations governing EIS preparation, where necessary information is incomplete or unavailable, the incremental-step biological opinion together with any other relevant scientific data that may be available constitute the "existing credible scientific evidence" that only then has to be summarized for incorporation into the environmental document. By applying to that "evidence" an accepted predictive methodology, the action agency, MMS, will be able to provide an "evaluation" of the potential impacts of its lease sales on species and habitat that satisfies NEPA standards without requiring redundant analyses or otherwise delaying the decisionmaking process.

The value of NEPA as a *comprehensive* environmental review authority is especially evident in circumstances such as those presented in the foregoing example where two or more statutes combine to focus attention and concern on a single environmental factor. NEPA and the CEQ regulations[185] stand as a constant reminder to the action agency that other environmental factors must be considered and integrated into the decisionmaking process. At the same time, evaluation under NEPA of uncertain effects, whether to endangered species and habitat or to any other aspect of the environment, does not stop with issuance of the EIS because the act also requires "that agencies take a 'hard look' at the environmental effects of their planned action, even after a proposal has received initial approval."[186]

Striking a Balance

The OCS program provides a major portion of the nation's natural gas and oil supplies and contributes to economic growth and to the federal treasury. But the program can also affect the coastal and marine ecosystems. In some highly sensitive ecosystems, the risks of environmental damage may be too great for development to proceed. On June 26, 1990, President Bush decided to delay leasing decisions in certain sensitive OCS areas pending collection and consideration of additional environmental information. The President also called for strengthening the OCS program to achieve the goal of a "much more carefully targeted OCS program, one that is responsive to local concerns, to environmental concerns, *and* to the need to develop prudently our nation's domestic energy resources."[187] At the same time, however, President Bush has expressed his belief "that there are significant offshore areas where we can and must go forward with resource development . . . [but in a manner designed] to achieve a *balance* between the need to provide energy for the American people and the need to protect unique and sensitive coastal and marine environments."[188] And when the decision to go forward with resource development in those areas is made, NEPA and the CEQ regulations will foster the effective, efficient integration of scientific and technical information regarding the resource potential of each area considered for leasing and the environmental, social, and economic effects of oil and gas developmental activities.

The Future of Integration

For this nation to respond meaningfully and efficiently to existing as well as emerging environmental problems, future environmental management efforts must revolve around the concept of integration. This observation is as sound today as it was 20 years ago when the late Senator Henry Jackson, the driving force behind formulation and enactment of NEPA, remarked that

> *[t]he contemplative consideration of general directions, the anticipation of emerging problems, and the design of new decision criteria are critically important; though they are not dramatic and, thus, seldom newsworthy. Fulfilling these functions will not capture public attention the way the latest pronouncement on mercury poisoning, a major oil spill, or the Alaska pipeline can. In the final analysis, however, man's ability to survive on this earth and to enjoy quality social, cultural, and aesthetic conditions and experiences will not turn upon our handling of a single contaminant, or our decision on a particular oil spill or construction proposal. It will turn on our ability to develop policies and decisionmaking models which integrate environmental concerns along with the full range of other important human values.*[189]

A recent U.S. EPA Science Advisory Board report addressing the environmental challenges that confront society today reached essentially the same conclusion that Senator Jackson did 20 years ago, namely, that to meet those challenges "national policy affecting the environment must become more integrated and more focused on opportunities for environmental improvement than it has in the past."[190] The report continued:

> *The environment is an interrelated whole, and society's environmental protection efforts should be integrated as well. Integration in this case means that government agencies should assess the range of environmental problems of concern and then target protective efforts at the problems that seem to be the most serious. It means that society should use all the tools—regulatory and non-regulatory alike—that are available to protect the environment. It*

> *means that controlling the end of the pipe where pollutants enter the environment, or remediating problems caused by pollutants after they have entered the environment, is not sufficient. Rather, waste-generating activities have to be modified to minimize the waste or to prevent the waste from being generated at all. Most of all, integration is critically important because significant sources of environmental degradation are embedded in typical day-to-day personal and professional activities, the cumulative effects of which can become serious problems. Thus protecting the environment effectively in the future will require a more broadly conceived strategic approach, one that involves the cooperative efforts of all segments of society.*[191]

Has the nation come full circle in the evolution of its thinking about the environment? Or was it simply overwhelmed to the point of distraction in the 1980s by a series of discrete environmental problems (such as toxic waste and pesticide residues) that collectively represented a severe threat to human health, a threat that always "arouses a much more intense interest than any esthetic, economic, or social impact"?[192] Whatever the explanation, the nation has come to recognize anew that "response to human health risks as compared to ecological risks is inappropriate, because, in the real world, there is little distinction between the two. Over the long term, ecological degradation either directly or indirectly degrades human health and the economy."[193]

What the United States discovered in the 1960s—that people must deal with the environment as a comprehensive, integrated whole—the nation is rediscovering in the 1990s and—at last—beginning to practice. Integrating the multitude of environmental laws and policies that govern and affect every citizen will mean becoming reacquainted with NEPA, not just as a "process" to be reckoned with, but as the United States' "comprehensive national policy on environmental management."[194]

From the standpoint of the "process" as applied to federal agency decisionmaking, however, the CEQ implementing regulations supply the integrative tools that are needed to balance the objectives of all applicable policies. But as the case studies developed in this chapter reveal, the effective application of those tools to federal programs requires considerable effort and forethought. Recently CEQ, in cooperation with EPA, sponsored a workshop to identify opportunities for and possible barriers to more effective integration of NEPA with other environmental review requirements. The workshop focused on problems arising in the energy, transportation, commercial development, and natural resource areas. The knowledge gained from those proceedings should assist in furthering the goal of integrated environmental management and decisionmaking.

Selected NEPA Cases in 1990

This section highlights NEPA decisions reported by the United States Supreme Court and by federal circuit and district courts during 1990.

United States Supreme Court

"Standing" in NEPA Litigation

Lujan v. *National Wildlife Federation*

In Lujan v. *National Wildlife Federation*,[195] the United States Supreme Court was asked to confer standing on plaintiffs who had alleged in affidavits the use of public lands "in the vicinity" of land that was the subject of 2 out of 1,250 Bureau of Land Management (BLM) orders. These orders, plaintiffs claimed, would open public lands to mining activities, thereby destroying their natural beauty. Plaintiffs challenged all of the 1,250 BLM orders, claiming violations of the National Environmental Policy Act (NEPA) and the Federal Land Policy and Management Act (FLPMA).

The district court, ruling on defendants' motion for summary judgment,[196] found that plaintiffs had no standing to seek judicial review. Specifically the court held that even if the affidavits claiming use of lands "in the vicinity" of lands that were the subject of two BLM orders were sufficient to challenge those two particular orders, they were not sufficient to allow a challenge to each of the 1,250 individual orders.[197] The Court of Appeals for the District of Columbia Circuit reversed, finding the affidavits sufficient to confer standing to challenge the two individual orders and that standing to challenge those orders conferred standing to challenge all 1,250 orders.[198]

Reversing the Court of Appeals in a 5-4 decision authored by Justice Scalia, the Supreme Court acknowledged that neither NEPA nor FLPMA provides a private right of action for violations of its provisions. Rather an injured party must seek relief under the Administrative Procedure Act (APA). To demonstrate standing under APA, a plaintiff must identify some final agency action that affects him or her *and* must show he or she has suffered a legal wrong because of the agency action or is adversely affected by that action within the meaning of a relevant statute. To be "adversely affected within the meaning of a statute," a plaintiff must be within the "zone of interests" sought to be protected by the statutory provision that forms the basis of the complaint.

Using this test of standing, the Court found that plaintiffs' interest in recreational use and aesthetic enjoyment of the federal lands were within the "zone of interests" protected by NEPA and FLPMA. However, the Court concluded that plaintiffs, by simply claiming use "in the vicinity" of immense tracts of land managed by BLM, had not shown they would be "adversely affected" by the BLM actions. Moreover the Court found that plaintiffs were attempting to challenge BLM operation of its land management program generally, not a final agency action in particular. Given these findings, the Court ruled that plaintiffs had not set forth "specific facts" in their affidavits sufficient to survive defendants' motion for summary judgment.

A dissent authored by Justice Blackmun noted that the showing required to overcome a motion for summary judgment is more extensive than that required for a motion to dismiss but concluded that the allegations in the affidavits were adequate to defeat a summary judgment motion. The dissent emphasized that the question was not whether plaintiffs had demonstrated standing, but whether the affidavits before the district court established that a genuine issue existed for trial.

Circuit Courts

Timber Harvesting

Tenakee Springs v. *Clough*

In 1990 the United States Court of Appeals for the Ninth Circuit was asked to resolve disputes concerning timber harvesting in the Pacific Northwest and Alaska. In *Tenakee Springs* v. *Clough,*[199] plaintiffs sought a preliminary injunction to stop timber harvesting in the Tongass National Forest under the terms of a 50-year contract between the USDA Forest Service and Alaska Pulp Company that was entered into in 1956. Plaintiffs alleged that the supplemental environmental impact statement (EIS) prepared by the Forest Service for the harvest failed to consider harvesting alternatives beyond what was required under the contract and had failed to consider cumulative impacts. The Forest Service asserted that such alternatives could not be considered because they would result in a violation of the terms of its contract with Alaska Pulp.

The district court denied the request for a preliminary injunction, finding that plaintiffs had failed to demonstrate any likelihood of success on the merits. The Ninth Circuit reversed the district court's holding and remanded the case back to that court.

In its decision, the court of appeals noted that the contract had been amended 11 times in the course of its history and that the Forest Service had not explained in its supplemental EIS why the contract could not be amended further, particularly in light of Forest Service regulations allowing it to modify or cancel any contract that would result in "serious environmental degradation or resource damage."[200] The court held that the Forest Service's failure to discuss or evaluate the consequences of terminating, suspending, or amending its contract raised a serious question of NEPA compliance. The court also concluded that the Forest Service had not adequately assessed the cumulative impacts of harvesting under the Alaska Pulp contract and other foreseeable timber sales in the area. For these reasons, the court found that plaintiffs had demonstrated a likelihood of success on the merits warranting the issuance of a preliminary injunction.

Marble Mountain Audubon Society v. *Rice*

The Ninth Circuit examined a fire-recovery timber sale in Oregon's Klamath National Forest in *Marble Mountain Audubon Society* v. *Rice*.[201] After a forest fire in 1987, the Forest Service began to plan the salvage and rehabilitation of the damaged area and prepared a draft and final EIS that considered the environmental impacts of nine alternative salvage and harvest proposals. The alternative selected called for logging of some green timber as well as the fire-killed timber and for the addition of six miles of logging roads.

Alleging that the final EIS failed to adequately consider the unique value of the area as the only significant biological corridor between two wilderness areas, plaintiffs sought declaratory and injunctive relief. The district court granted summary judgment in favor of the Forest Service, stating that the NEPA claims were barred by section 312 of Pub. L. No. 101-121[202] and, alternatively, that the final EIS adequately addressed the biological corridor issue.

The Ninth Circuit reversed. Recognizing the "strong presumption in favor of judicial review of administrative action" and "narrowly constru[ing]" section 312's prohibition against judicial review,[203] the court found that the biological corridor issue was not a generic issue that would enable plaintiffs to challenge the entire Timber Management Plan for the Klamath National Forest in contravention of section 312.

The court also concluded that, based on the record before it, the Forest Service had not taken a "hard look" at the impact of the selected salvage and harvest alternative on the biological corridor. The court found that the Forest Service's conclusion that the preservation of a half-mile corridor would be sufficient was "without supporting documentation" and found "no discussion" of the corridor issue in either of two underlying documents relied upon by the Forest Service (a 1967 Multiple Use Plan and a 1974 Klamath National Forest Timber Management Plan and accompanying EIS).[204] Having issued an order enjoining any logging or road building, the court remanded the case to the district court for further proceedings.

Seattle Audubon Society v. *Robertson*

In another case involving commercial logging, *Seattle Audubon Society* v. *Robertson*,[205] the Ninth Circuit considered a consolidated challenge to BLM and Forest Service forest management activities under NEPA and other statutes. The Portland Audubon Society had originally brought suit against BLM in 1987, and the Seattle Audubon Society had challenged Forest Service decisions in 1989. Congress, attempting to resolve the issues raised in these cases, passed section 318 of the Department of the Interior and Related Agencies Appropriations Act for Fiscal Year 1990,[206] which went into effect on October 23, 1989.

While section 318 sets a limit on timber sales, sets out a timber management plan for national forest and BLM land in Oregon and Washington, and prohibits sales in identified spotted owl habitat areas, it also

> *determines and directs that management of areas according to subsections (b)(3) and (b)(5) of this section on the thirteen national forests in Oregon and Washington and Bureau of Land Management lands in western Oregon known to contain northern spotted owls* is adequate consideration for the purpose of meeting the statutory requirements that are the basis for the consolidated cases *captioned Seattle Audubon Society et al. v. F. Dale Robertson, Civil No. 89-160 and Washington Contract Loggers Assoc. et al. v. F. Dale Robertson, Civil No. 89-99 (order granting preliminary injunction) and the case Portland Audubon Society et al. v. Manuel Lujan, Jr., Civil No. 87-1160-FR.*[207]

Based on section 318, the district court in *Seattle Audubon* vacated its preliminary injunction, and the district court in *Portland Audubon* granted the government's motion to dismiss.

On appeal, plaintiffs in the consolidated cases challenged section 318 as violative of the separation of powers doctrine and thus unconstitutional. The Ninth Circuit agreed.

The court stated that, for the first time, Congress in enacting section 318 had endeavored to instruct the federal courts to reach a particular result in specified pending cases. The judicial power of the United States, however, lies in the federal courts and not in Congress. The court held that although Congress could modify the law underlying pending cases, it could not direct the courts to decide the cases in a particular way without first repealing or amending the underlying laws.

Declaratory Judgment Act

Collin County, Texas v. *Homeowners Association for Values Essential to Neighborhoods (HAVEN)*

In *Collin County, Texas* v. *Homeowners Association for Values Essential to Neighborhoods (HAVEN),*[208] the Court of Appeals for the Fifth Circuit was asked to review a district court's grant of summary judgment in favor of the plaintiff county under the Declaratory Judgment Act. The Texas State Department of Highways and Public Transportation, in conjunction with the Federal Highway Administration, prepared an EIS for an eight-lane highway project outside of Dallas known as SH 190. The defendant citizens' group opposed the project claiming adverse impacts to their community and indicated their intention to challenge the adequacy of the EIS in court.

Collin County, through which the highway would pass and which sought to have the highway built as soon as possible, asked the district court to issue a judgment declaring that the final EIS was sufficient as a matter of law. The county's motion was granted.

On appeal, however, the court of appeals found that the county could not use the Declaratory Judgment Act to forestall potential litigation by a citizen's group that might delay construction of the highway when the citizen's group has no cause of action against the county:

> *We recognize the local governments' interests in the outcome of potential litigation between HAVEN and the appropriate highway authority over SH 190. However, these interests are not adverse legal interests vis-a-vis HAVEN's potential NEPA claim—the only substantive issue in this case.*[209]

The declaratory judgment was vacated and the action dismissed.

"Small Federal Handle"

Macht v. *Skinner*

The District of Columbia Court of Appeals examined the extent to which federal involvement in a nonfederal project may "federalize" the project for purposes of NEPA compliance in *Macht* v. *Skinner*.[210] In this case, the Maryland Mass Transit Administration decided to build a 22.5-mile light rail line near Baltimore, to be financed solely by state and local governments. There was, however, some federal involvement. First, the state needed to obtain a section 404 permit[211] from the Army Corps of Engineers for 3.58 acres of wetlands. Further, using federal funds, Maryland began consideration of three extensions to the rail line. The federal grant, from the Urban Mass Transit Administration (UMTA), was provided to the state for assistance in preparing alternative analyses and draft EISs for the contemplated extensions.

The plaintiffs sued the federal agencies, claiming that there was sufficient federal involvement in the rail project to constitute a "major federal action" requiring compliance with NEPA. Affirming the lower court, the court of appeals held that neither the Army Corps wetlands permit nor the UMTA grant was enough to transform the entirely state-funded project into a federal action.[212]

With respect to the UMTA grant for the preliminary environmental analyses, the court stated that "NEPA does not require UMTA to prepare an EIS until it proposes or decides to participate in a project that will affect the environment."[213] Addressing the Army Corps permit issue, the court noted that the plaintiffs "correctly assert that federal involvement in a nonfederal project may be sufficient to 'federalize' the project for purposes of NEPA."[214]

The court characterized the issue as "whether the federal participation in the project is so substantial that the state should not be allowed to go forward until all the federal approvals have been granted in accordance with NEPA."[215] In this case, the court found that the Army Corps had discretion only over a negligible portion of the entire project, that the only federal involvement in the 22.5-mile state portion of the project was the wetlands permits, and that the state had not entered into a financial partnership with the federal government. "NEPA therefore provides no basis for enjoining Maryland's construction of the Light Rail Project."[216]

Cumulative Impacts

National Wildlife Federation v. *Federal Energy Regulatory Commission*

The Court of Appeals for the District of Columbia Circuit also addressed cumulative impacts in *National Wildlife Federation* v. *Federal Energy Regulatory Commission*,[217] and upheld a license issued by the Commission (FERC) for the first phase of a hydroelectric plant in Arkansas. The EIS prepared for the project looked only at the environmental impacts of Phase I, although construction of Phase II, while not inevitable, was reasonably foreseeable. The plaintiffs had challenged the issuance of the license for Phase I, asserting that FERC violated NEPA by not assessing the potential impacts of Phase II in deciding whether to approve Phase I. The court reasoned that Phase II of the project was not yet proposed and that "NEPA merely requires an agency to consider all other *proposed* actions that may, along with the proposed action in issue, have a cumulative or synergistic impact on an environment."[218]

It should be noted that the court seems to have confused the requirement to consider all connected or cumulative *actions* together in the same comprehensive EIS,[219] with the requirement to assess the cumulative *impacts* of the proposal and other reasonably foreseeable future actions.[220] Only actual proposals, as defined in the Council on Environmental Quality (CEQ) regulations,[221] need be considered together in one EIS. Once the scope of the EIS has been determined, however, the agency is required to look at cumulative impacts of "other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions."[222]

Functional Equivalence and EPA Compliance with NEPA

State of Alabama ex rel. Siegelman v. *Environmental Protection Agency*

In *State of Alabama ex rel. Siegelman* v. *Environmental Protection Agency,*[223] the Court of Appeals for the Eleventh Circuit was asked to review whether the Environmental Protection Agency's compliance with the Resource Conservation and Recovery Act (RCRA) was the "functional equivalent" of compliance with NEPA. Plaintiffs had brought suit against EPA for issuing a final operating permit to a hazardous waste management facility without preparing an EIS. The district court had ruled that EPA was not required to comply with NEPA when discharging its permitting duties under RCRA since that act placed requirements on EPA that were functionally equivalent to the requirements of NEPA.

The court of appeals, while acknowledging that NEPA applies to all federal agencies, noted that most circuits have recognized that EPA does not have to comply with NEPA inasmuch as its own legislative mandate sets forth specific procedures for considering environmental issues that are the functional equivalent of the EIS process. The court found that RCRA is the functional equivalent, although not the structural or literal equivalent, and more specific counterpart of NEPA, and held that EPA did not have to comply with NEPA in deciding whether to issue a RCRA permit.

Schalk v. *Reilly*

Another case involving EPA compliance with NEPA is *Schalk* v. *Reilly.*[224] There, plaintiff asserted that EPA violated NEPA by failing to prepare an EIS for a proposed removal action under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Under CERCLA and the 1986 Superfund Amendments and Reauthorization Act (SARA), EPA is authorized to undertake or to order removal or remedial actions to protect public health, welfare, or the environment when it determines that release of a hazardous substance poses an imminent and substantial danger.

To facilitate expeditious cleanups of hazardous waste sites, however, CERCLA/SARA limits the availability of citizen suits to challenge particular cleanup actions:

> *No Federal court shall have jurisdiction under Federal law. . . to review any challenges to removal or remedial action selected. . . except. . .*
>
> *(4) An action. . . alleging that the removal or remedial action taken. . . or secured. . . was in violation of any requirement of*

> *this chapter. Such an action may not be brought with regard to a removal where a remedial action is to be undertaken at the site.*[225]

The court, citing the "obvious meaning" of the statute, concluded that when a CERCLA remedy has been selected, no challenge to the cleanup, including a NEPA challenge, may be made prior to completion of the remedy.[226]

District Courts

Condemnation Actions

United States v. *27.09 Acres of Land*

District courts in Illinois and New York examined the United States Postal Service's (USPS) NEPA compliance for condemnation actions. In *United States* v. *27.09 Acres of Land*,[227] the USPS brought a condemnation action to acquire land owned by Westchester County, New York, for a postal facility. The county resisted, arguing that the USPS could not condemn the land until it had completed its NEPA process. An environmental assessment (EA) had been prepared for the site, but the USPS had begun the condemnation proceeding for the property prior to completing the public comment period as required by USPS regulations and prior to issuing a finding of no significant impact (FONSI) as required by the CEQ regulations.

The county argued that the attempted condemnation of the site represented a commitment of resources ($10 million) that precluded unbiased consideration of other, less damaging alternative sites and predetermined the outcome of the NEPA review. The USPS responded that, while it must comply with NEPA prior to actual construction of the facility, such compliance need not precede condemnation because the agency may resell the land or put it to a different use if it decides not to construct the facility there.

The district court sided with the USPS, stating that the condemnation action did not represent an irretrievable commitment of resources and that if, once the NEPA process had been completed, the USPS decides not to build, the agency could dispose of the land or use it for a different purpose. The court found that a condemnation action was separable from the issue of the use to which the land would be put.

Village of Palatine v. *United States Postal Service*

However the decision in *Village of Palatine* v. *United States Postal Service*[228] demonstrates the difficulty of pre-decisional acquisition of property. There the village sought to enjoin the USPS from constructing a mail distribution center on land the USPS had purchased from a private owner. In 1987, before conducting any environmental analysis, the

USPS purchased an option on the parcel of land in question for a nonrefundable $400,000; if the option were exercised, the purchase price was to be $9.5 million.

The option was good until March 31, 1988. The USPS issued a draft EA on March 23, the option was exercised on March 31, and a final EA and FONSI were issued in May 1988.

At the urging of the village, the USPS agreed in late 1988 to consider an alternative site. As the court stated, although the USPS agreed to study another site and even conceded that the alternative was viable, the agency indicated that it wanted to proceed at the original site because of the time and money it had already invested in that location.

The village filed suit, seeking to enjoin the USPS from constructing the facility on the site it had acquired until after it had complied with NEPA and other pertinent statutes and regulations. In ruling on the USPS motion to dismiss, the court recognized that the USPS had substantially modified the proposed facility after issuance of the EA in May 1988 and concluded that the record did not demonstrate that the USPS had fully considered all the relevant environmental factors in its EA.

Further, the court stated that the USPS was obligated to evaluate a range of alternatives, including alternative sites. While the EA indicates that the USPS has considered 28 sites, it failed to adequately explain why the USPS had rejected those alternative sites. The USPS motion to dismiss was denied.

Injunctive Relief

Elliott v. *U.S. Fish and Wildlife Service*

The Vermont district court was asked in *Elliott* v. *U.S. Fish and Wildlife Service*[229] to issue a temporary restraining order and a preliminary injunction to halt release of chemical "lampricides" into streams feeding into Lake Champlain. After preparing an EIS and a record of decision in accordance with NEPA, the Fish and Wildlife Service (FWS) had decided to release the chemicals to reduce the population of sea lampreys—a species of parasitic fish that preys on sports fish—in the lake. The plaintiffs claimed that FWS had violated NEPA and moved to enjoin the project, arguing that the alleged procedural violation of NEPA demonstrated "irreparable injury." The court disagreed:

> *Violations of the procedures required by NEPA do not by themselves constitute irreparable harm sufficient to justify injunctive relief. The alleged harm must stem from the government action sought to be enjoined and must be of the sort that the statutes relied upon are designed to avert.*[230]

The motion for a temporary restraining order and an injunction was denied.

Climate Change Impacts

Foundation on Economic Trends v. *Watkins*

The issue of assessing climate change impacts in the NEPA process was presented in *Foundation on Economic Trends* v. *Watkins*.[231] In that case, plaintiffs filed suit against the Departments of Energy, Interior, and Agriculture, seeking to enjoin certain actions taken by those agencies that, plaintiffs stated, contribute to the problem of global warming. Plaintiffs alleged that the agencies were required to assess the impacts of those actions and their contributions to the "greenhouse effect" in NEPA documents. Ruling on the defendants' motion to dismiss on procedural grounds, the district court held that plaintiffs were not seeking an advisory opinion, that the actions challenged were ripe for review, and that plaintiffs did have standing to sue.

With respect to the standing issue, plaintiffs asserted that the injury they suffered was deprivation of information resulting from the defendants' failure to comply with NEPA. The court noted that "the concept of informational standing is well recognized in this circuit,"[232] and found that

> *the Plaintiffs have specifically identified federal actions which they allege fail to comply with NEPA. Moreover, they have specifically identified the environmental zone, the global atmosphere, which is affected by the government's actions.*[233]

Defendants' motion to dismiss was denied.[234]

Extraterritorial Application of NEPA

Greenpeace USA v. *Stone*

In *Greenpeace USA* v. *Stone*,[235] the United States District Court for the District of Hawaii examined the application of NEPA to the removal of U.S. chemical munitions stored in the Federal Republic of Germany (FRG) and transport of the munitions to Johnston Atoll, a U.S. territory in the Pacific Ocean, for subsequent destruction. Pursuant to commitments that President Reagan and President Bush had made to German Chancellor Kohl to remove the munitions, and also in accordance with a congressional mandate that the munitions be destroyed, the Department of the Army undertook a joint plan with the West German Army to remove the chemical munitions from FRG territory. The United States would then transport the munitions to Johnston Atoll for destruction at the Johnston Atoll Chemical Agent Disposal System (JACADS).

The Army had previously prepared two EISs for JACADS, one for its construction and its operation to destroy a stockpile of chemical munitions already stored on Johnston Atoll, and one for the disposal of the solid and liquid wastes that the facility would produce. Following the decision and commitment to remove the munitions from the FRG, the Army proposed to use JACADS to destroy them and prepared a third JACADS EIS addressing the impacts associated with the handling, storage, and destruction of those munitions at the Johnston Atoll facility.

In addition, pursuant to Executive Order No. 12114 (Environmental Affects Abroad of Major Federal Actions), the Army prepared a Global Commons Environmental Assessment analyzing the environmental impacts of the tranoceanic shipment of the munitions from an FRG port to Johnston Atoll. In accordance with the Executive Order's provisions regarding major federal actions abroad in which the host nation is participating, the Army did not undertake analysis of the environmental impacts of movement of the munitions within the FRG.

Plaintiffs argued that the Army was required by NEPA to prepare a single, comprehensive EIS covering the removal, shipment, and destruction of the munitions and sought to enjoin removal of the munitions from the FRG. In ruling on plaintiffs' motion for a preliminary injunction,[236] the district court stated that "it is not convinced NEPA applies extraterritorially to the movement of munitions in Germany or their transoceanic shipment to Johnston Atoll."[237]

The court recognized that "the language of NEPA indicates that Congress was concerned with the global environment and the worldwide character of environmental problems," but that actions under NEPA "should be taken 'consistent with the foreign policy of the United States.'"[238] "Congress intended to *encourage* federal agencies to consider the global impact of domestic actions and *may* have intended under certain circumstances for NEPA to apply extraterritorially."[239] However, "the court *must* take into consideration the foreign policy implications of applying NEPA within a foreign nation's borders to affect decisions made by the President in a purely foreign policy matter."[240]

With respect to the need to assess the environmental impacts of its actions within the FRG and in the circumstances of this case, the court concluded that:

> *Imposition of NEPA requirements to that operation would encroach on the jurisdiction of the FRG to implement a political decision which necessarily involved a delicate balancing of risks to the environment and the public and the ultimate goal of expeditiously ridding West Germany of obsolete chemical unitary munitions.*[241]

Further the court found that "[t]he transoceanic movement of the munitions is a necessary consequence of the stockpile's removal from West Germany," and thus "implicates many of the same foreign policy concerns which affect the movement of the weapons through West Germany. . . ."[242]

For the transoceanic phase of the action, the Army did prepare an environmental assessment under Executive Order No. 12114. Although the court "cannot conclude...that Executive Order 12114 preempts application of NEPA to *all* federal agency actions taken outside the United States,"[243] the court was persuaded, again under the circumstances of this case, that NEPA did not require the Army to consider the global commons portion of the action in the same EIS that covers the Johnston Atoll facility.

Based on these findings, the court concluded that plaintiffs had not demonstrated a likelihood of success on the merits sufficient for the imposition of a preliminary injunction. Plaintiffs' motion for such injunctive relief was denied.

NEPA Trends

Over the past eight years, the number of cases filed against federal departments and agencies on the basis of the National Environmental Policy Act (NEPA) has dropped consistently, and 1989 was no exception. Table 5-1 indicates that during 1989 only 57 cases were filed, almost half the number of 1988. The number of injunctions is down by nearly half with only five issued in 1989.

The Department of Agriculture and the Department of Transportation were the agencies that had the largest number (15 lawsuits each) of NEPA cases filed against them. Table 5-2 shows that fewer cases were filed against other agencies.

Table 5-3 lists causes of action in NEPA cases filed. The lack of an environmental impact statement was the most frequent cause of action for most cases filed in 1989. Inadequate environmental impact statements were cited as the cause of complaints in half the cases, as in the 1988 survey.

Table 5-4 shows individual and citizen groups as the most frequent plaintiffs, with 28 in 1989 cases. Environmental groups were not far behind with a total of 23. Once again, the number has decreased from past years. Table 5-5 presents the number of plaintiffs and issues by agency.

Table 5-6 contains draft, final, and supplemental environmental impact statements filed by federal agencies during 1990. The total number of EISs filed in 1990 was 477.

Table 5-1.—Cumulative NEPA litigation survey, 1970–1989.*

YEAR	CASES FILED	INJUNCTIONS	MOST FREQUENT DEFENDANT	MOST FREQUENT PLAINTIFF	MOST COMMON COMPLAINT	SECOND MOST COMMON COMPLAINT
1974	189		DOT, HUD			
1975	152					
1976	119		DOT, DOI, HUD	Citizen and environmental groups	No EIS	Inadequate EIS
1977	108		DOT, DOD, DOI	Citizen and environmental groups	No EIS	Inadequate EIS
1978	114		DOT, DOD, DOI, HUD, EPA	Citizen and environmental groups, individuals	No EIS	Inadequate EIS
1979	139	12	DOT, HUD DOI, USDA, DOD	Environmental groups, citizen groups, individuals	No EIS	Inadequate EIS
1980	140	17	DOT, DOI, DOD, HUD, EPA	Individuals or citizen groups, environmental groups	No EIS	Inadequate EIS
1981	114	12	DOD, DOT, DOI, USDA, HUD, NRC	Environmental groups, individuals, or citizen groups	No EIS	Inadequate EIS
1982	17	19	DOI, COE, DOT, USDA, HUD, EPA	Individuals or citizen groups, environmental groups	Inadequate EIS	No EIS
1983	146	21	DOI, DOT, ARMY, FERC, NRC	Individuals or citizen groups, environmental groups	No EIS	Inadequate EIS

Table 5-1.—Continued.

YEAR	CASES FILED	INJUNCTIONS	MOST FREQUENT DEFENDANT	MOST FREQUENT PLAINTIFF	MOST COMMON COMPLAINT	SECOND MOST COMMON COMPLAINT
1984	89	14	USDA, DOI, DOT	Environmental groups, individuals or citizen groups	Inadequate EIS	No EIS
1985	77	8	DOT, DOI, COE, FERC	Environmental groups, individuals or citizen groups	No EIS	Inadequate EIS
1986	71	16	DOT, DOI, USDA	Individuals or citizen groups, environmental groups	No EIS	Inadequate EIS
1987	69	3	DOI, DOT, USDA	Environmental groups, individuals or citizen groups	No EIS	Inadequate EA and EIS
1988	91	7	COE, USDA, DOI, DOT	Environmental groups, individuals or citizen groups	No EIS	Inadequate EIS
1989	57	5	USDA, DOT	Individuals or citizen groups, environmental groups	No EIS	Inadequate EIS

*1970–1975: A cumulative survey on these years was published in the 1976 CEQ Annual Report. By June 30, 1975, 332 NEPA cases had been completed, resulting in 54 injunctions; 322 cases were still pending with 65 injunctions. The most frequent defendants were the departments of Transportation and Housing and Urban Development.

Table 5-2.—NEPA cases by federal agency, 1989.

AGENCIES	CASES FILED	1989 CASES RESULTING IN INJUNCTIONS	INJUNCTIONS IN 1989 FROM PRE-1989 CASES
Environmental Protection Agency	1	0	0
Federal Energy Regulatory Commission	1	0	0
Interstate Commerce Commission	5	0	0
National Aeronautics and Space Administration	1	0	0
Nuclear Regulatory Commission	3	0	0
Department of Agriculture	15	2	2
Department of the Army	1	0	0
Department of the Army: U.S. Army Corps of Engineers	5	1	1
Department of Commerce	2	0	0
Department of Energy	3	0	0
Department of Housing & Urban Development	3	0	0
Department of Interior	9	1	0
Department of Transportation	15	1	0
Department of Navy	2	0	0
Total	66	5	3

Table 5-3.—Types of complaints filed under NEPA, 1989.

CAUSES OF ACTION	1989 CASES	PRE-1989 CASES RESULTING IN INJUNCTIONS IN 1989
Inadequate environmental impact statement	16	2
No environmental impact statement, when one should have been prepared	34	1
Inadequate environmental assessment	17	0
No environmental assessment, when one should have been prepared	4	0
No supplemental environmental impact statement, when one should have been prepared	5	0
Other	4	0
Total	80	3

Table 5-4.—Plaintiffs for NEPA lawsuits, 1989.

TYPES OF PLAINTIFFS	1989 CASES	PRE-1989 CASES RESULTING IN INJUNCTIONS IN 1989
Environmental groups	23	2
Individuals or citizen groups	28	1
State governments	3	1
Local governments	2	0
Business groups	11	0
Property owners or residents	10	0
Indian tribes	2	0
Total	79	4

Table 5-5.—Statistics on plaintiffs and issues for 1989 cases, by federal agency.

AGENCY	EPA	FERC	ICC	NASA	NRC	USDA	ARMY	COE	DOC	DOE	HUD	DOI	DOT	NAVY
Plaintiff														
Environmental groups			1		1	8			2	3		6	1	1
Individuals or citizen groups			2	1	2	4	1	3			3	1	10	1
State governments		1	1					1						
Local governments													2	
Businesses	1	1	1			4							4	
Property owners or residents		1	2			1						1	5	
Indian tribes								1				1		
Total	1	3	7	1	3	17	1	5	2	3	3	9	22	2
Issue														
Inadequate EIS		1		1		4		1		1		4	3	1
No EIS	1				2	9	1	3	2	1		4	10	1
Inadequate EA		1	1			4	1	1			3	1	4	1
No EA			3										1	
No supplemental EIS												3	2	
Other			1		1	1				1				
Total	1	2	5	1	3	18	2	5	2	3	3	12	20	3

Table 5-6.—Environmental impact statements filed by federal agencies during 1990.

AGENCY	TOTAL BY SUBJECT MATTER	TOTALS
Department of Agriculture		136
Natural gas and oil: drilling and exploration	3	
Natural gas and oil: transportation, pipeline, storage	3	
Power facilities: fossil	2	
Power facilities: transmission	2	
Municipal and industrial water supply systems (not multi-purpose)	1	
Watershed protection and flood control	9	
Road construction	1	
Land acquisition or disposal, management/ jurisdiction transfer	1	
Parks, recreation areas, wilderness areas, national seashores	34	
Forestry and range management	70	
Mining (non-energy)	4	
Comprehensive resource management	1	
Pesticides and herbicides use	2	
Weather modification and methodology	2	
Miscellaneous information	1	

Table 5-6.—Continued.

AGENCY	TOTALS BY SUBJECT MATTER	TOTALS
Department of Commerce		8
Wetlands, estuary, and ocean use (sanctuary, disposal, etc.)	5	
Fisheries	3	
Department of Defense		
Department of the Air Force		19
Military installations (conventional, chemical, nuclear, etc.)	17	
Space programs	1	
Sewage treatment and sewage facilities	1	
Department of the Army		9
Defense systems	1	
Military installations (conventional, chemical, nuclear, etc.)	5	
Munitions facilities	2	
Housing subdivisions and new communities	1	
Department of the Army, Corps of Engineers		46
Military installations (conventional, chemical, nuclear, etc.)	1	
Beach erosion, hurricane protection, river/lake bank stabilization	3	
Navigation	7	
Multi-purpose impoundments	5	
Dredge and fill	6	
Watershed protection and flood control	19	
Other water projects	3	
Bridge permits	1	
Parks, recreation areas, wilderness areas, national seashores	1	
Department of the Navy		19
Power facilities: conservation and other	1	
Military installations (conventional, chemical, nuclear, etc.)	14	
Dredge and fill	2	
Road construction	1	
Research and development (not already covered)	1	
Department of Energy		11
Nuclear Development (e.g., fuel)	2	
Natural gas and oil: transportation, pipeline storage	2	
Regulatory: allocation, pricing	1	
Power facilities: hydroelectric	1	
Power facilities: transmission	1	
Radioactive waste disposal	2	
Research and development (not already covered)	2	
Environmental Protection Agency		31
Mining	3	
Power facilities: fossil	1	
Hazardous and toxic substance disposal	2	
Sewage treatment and sewage facilities	7	
Municipal and industrial water supply systems (not multi-purpose impoundments)	1	
Mining (non-energy)	1	
Regulatory activities (not already covered)	3	
Wetlands, estuary, and ocean use (sanctuary, disposal, etc.)	13	

Table 5-6.—Continued.

AGENCY	TOTALS BY SUBJECT MATTER	TOTALS
General Services Administration		4
Buildings for federal use	4	
Department of Housing and Urban Development		5
Pesticides and herbicides use	1	
Housing subdivisions and new communities	4	
Department of the Interior		68
Nuclear development (e.g., fuel reactors)	1	
Mining	6	
Natural gas and oil: drilling and exploration	9	
Power facilities: hydroelectric	2	
Hazardous and toxic substance disposal	1	
Municipal and industrial water supply system (not multi-purpose impoundments)	1	
Irrigation, desalination of return flows, agriculture water supply	2	
Multi-purpose impoundments	1	
Watershed protection and flood control	1	
Other water projects	1	
Road construction	1	
Land acquisition or disposal, management/ jurisdiction transfer	5	
Parks, recreation areas, wilderness areas, national seashores	14	
Wildlife refuges, fish hatcheries	3	
Forestry and range management	1	
Mining (non-energy)	7	
Comprehensive resource management	8	
Pesticides and herbicides use	2	
Housing subdivisions and new communities	1	
Miscellaneous information	1	
Tennessee Valley Authority		3
Mining	1	
Navigation	2	
Department of Transportation		100
Road construction	76	
Airport improvements	13	
Bridge permits	4	
Mass transportation	7	
Federal Energy Regulatory Commission		8
Natural gas and oil: transportation, pipeline, storage	3	
Power facilities: hydroelectric	5	
National Aeronautics and Space Administration		4
Space programs	4	
Department of Justice		6
Prison construction	6	
Total federal EISs		477

Key to Legal Citations and Explanation of Abbreviations

Reported Decisions, Notices, and Debates

North Slope Borough v. *Andrus*, 486 F.Supp. 332, 345 (D.D.C. 1979), *aff'd in part, rev'd in part on other grounds*, 642 F.2d 589 (D.C. Cir. 1980). The decision in the case of North Slope Borough versus Andrus is reported at volume 486 of the Federal Supplement reporter (reporting decisions of the U.S. District Courts, in this case, a 1979 decision of the U.S. District Court in the District of Columbia beginning at page 332; succeeding page numbers, if any, contain the specific passage or proposition for which the citation is being offered; the decision was upheld (or affirmed) in part and overturned (or reversed) in part on other grounds unrelated to the proposition for which the citation to the earlier opinion is being offered at volume 642 of the Federal Reporter, Second Series (reporting decisions of the U.S. Courts of Appeals, in this case, a 1980 decision of the Court of Appeals for the District of Columbia Circuit) beginning at page 589.

The following authorities are similarly cited by volume, page number(s) and date of issuance:

[Vol.]	**U.S.** [Page]	United States Reports—decisions of the U.S. Supreme Court
	S.Ct.	West Publishing Co.'s report of cases decided by the U.S. Supreme Court
	Cong. Rec.	Congressional Record—compilation of Congressional debates
	Fed. Reg.	Federal Register—daily compilation of public regulations and legal notices of the federal government
	I.C.C.	Interstate Commerce Commission Reports— decisions of the Interstate Commerce Commission
	Envtl. L. Rptr.	Environmental Law Reporter—unofficial compilation of reported decisions and other material

Congressional Reports

S. Rep. No. 296, 91st Cong., 1st Sess. 4 (1969). Cited material appears in U.S. Senate Report Number 296, published during the 91st Congress, 1st Session in 1969, at page 4. H.R. Rep. No. indicates the U.S. House of Representatives' counterpart.

Statutory and Regulatory Authorities

42 U.S.C. § 4321 (1982). The statute or statutory language being cited, in this case the National Environmental Policy Act of 1969, is codified at title 42 of the main 1982 volume of the United States Code (containing the compilation of statutes currently in force), in section 4321; (West 1985) in a citation references the 1985 edition of West Publishing Co.'s annotated code.

40 C.F.R. § 1508.21 (1990). The regulation or regulatory language being cited is published in the 1990 edition of title 40 of the Code of Federal Regulations (containing the compilation of regulations currently in force), at section 1508.21.

Legislative Histories

[1976] U.S. Code Cong. & Admin. News 14, 58. The cited material, which generally has been drawn directly from Congressional reports and hearings, also may be found in the 1976 edition of the United States Code Congressional and Administrative News (containing a compilation of legislative histories and other such materials), beginning at page 14. Succeeding page numbers, if any, contain the specific passage or proposition for which the citation is being offered.

Notes and References

1. Jackson, H., "Overview on Environmental Problems," Lecture at the University of Pennsylvania Engineering School in Philadelphia, unpublished manuscript, March 31, 1971.

2. 42 U.S.C. § 4321 *et seq.* (1982).

3. Hardison, O.B., Jr., *Disappearing Through the Skylight: Culture and Technology in the Twentieth Century* 184 (New York: Penguin Group, 1989), p. 184.

4. Hayes, D., "Earth Day: one view," *EPA Journal* (Jan./Feb. 1990), 16(1): 24.

5. Compare S. Rep. No. 296, 91st Cong., 1st Sess. 4 (1969) ("We see increasing evidence of this inadequacy [to deal with environmental problems] all around us: . . . critical air and water pollution problems; diminishing recreational opportunity; continuing soil erosion; the degradation of unique ecosystems; needless deforestation; the decline and extinction of fish and wildlife species . . . and many, many other environmental quality problems") with 135 Cong. Rec. H6836, H6837 (daily ed. Oct. 10, 1989) ("We are concerned now—as we were when NEPA was enacted—about polluted rivers, dirty air, and unplanned development. But we did not worry then that Earth might someday suffer an even greater loss—the loss of the very features that distinguish it from its interplanetary neighbors: A healthy ozone layer; a proper balance between oxygen and carbon dioxide in the atmosphere; the ability to sustain human life") (statement of Congressman Studds).

6. Compare 115 Cong. Rec. 3698, 3700 (1969) ("What we should be doing is setting up institutions and procedures designed to anticipate environmental problems before they reach crisis stage. . . . It is far cheaper in human, social, and economic terms, to anticipate these problems at an early stage and to find alternatives before they require the massive expenditures we are now obligated to make to control air, water, and oil pollution") (statement of Senator Jackson) with Reilly, "Aiming Before We Shoot: The Quiet Revolution in Environmental Policy," Address to the National Press Club, Sept. 26, 1990 (U.S. EPA, Office of Communications and Public Affairs at p. 5) ("We need to take a broader, more integrated look at the range of environmental programs we administer, and the response tools available to us, with an eye toward finding the most efficient and effective ways to reduce risk. Among the tools identified by [EPA's] Science Advisory Board are research, public education and information, technical assistance, and market incentives. And above all, we need to mobilize a national effort to *prevent* pollution before it's created in the first place") (emphasis in original).

7. 115 Cong. Rec. 40,416 (1969) (statement of Senator Jackson).

8. 115 Cong. Rec. 29,059 (1969) (statement of Senator Church).

9. *Staff of Subcomm. on Science, Research, and Development of the House Comm. on Science and Astronautics*, 90th Cong., 2d Sess., *Report on Managing the Environment* 30 (Comm. Print 1968).

10. 115 Cong. Rec. 29,056 (1969) (statement of Senator Jackson).

11. *Library of Congress, Congressional Research Service, Environmental Policy Division, Congress and the Nation's Environment: Environmental Affairs of the 91st Congress, prepared for Senate Comm. on Interior and Insular Affairs*, 92d Cong., 1st Sess. xv (Comm. Print 1971).

12. See *Senate Comm. on Interior and Insular Affairs and House Comm. on Science and Astronautics*, 90th Cong., 2d Sess., *Congressional White Paper on A National Policy for the Environment* 11 (Comm. Print 1968): "The ultimate responsibility for protecting the human-serving values of our environment rests jointly with the legislative, executive, and judicial branches of our government."

13. See S. Rep. No. 296, 91st Cong., 1st Sess. 8 (1969): NEPA "will also provide a model and a demonstration to which State governments may look in their efforts to reorganize local institutions and to establish local policies conducive to sound environmental management."

14. *Congressional White Paper*, page 16: "The system of free enterprise democracy must integrate long-term public interests with private economic prosperity. A full range of incentives, inducements, and regulations must be used to link the public interest to the marketplace in an equitable and effective manner. Manufacturing, processing, and the use of natural resources must approach the goal of total recycle to minimize waste control and to sustain materials availability. Renewable resources of air and water must be maintained and enhanced in quality for continued use. A broad base of technologic, economic, and ecologic information will be necessary. The benefits of preventing quality and productivity deterioration of the environment are not always measurable in the marketplace. Ways must be found to add to cost-benefit analyses nonquantifiable, subjective values for environmental amenities (which cannot be measured in conventional economic terms)."

15. See 42 U.S.C. § 4331(c) (1982): "[E]ach person has a responsibility to contribute to the preservation and enhancement of the environment."

16. *Environmental Affairs of the 91st Congress*, page xv.

17. *Environmental Affairs of the 91st Congress*, page 12.

18. *Environmental Affairs of the 91st Congress*, page 245.

19. *Environmental Affairs of the 91st Congress*, page 245.

20. See for example, Fish and Wildlife Coordination Act of 1958, 16 U.S.C. § 661 *et seq*.; National Historic Preservation Act of 1966, 16 U.S.C. § 470 *et seq*.; Endangered Species Act of 1973, 16 U.S.C. § 1531 *et seq*.; and American Indian Religious Freedom Act of 1978, 42 U.S.C. § 1996.

21. *Report on Managing the Environment*, page 5 (emphasis supplied).

22. See S. Rep. No. 296, 91st Cong., 1st Sess. 14 (1969): "[T]he need to rationalize and better coordinate existing policies" for the environment extends not only to those areas afflicted by "the lack of a policy" but also to the "many specific and specialized legislative policies on some aspects of the environment."

23. Statement of CEQ Chairman Russell Train in *Hearings on Organizational Plans of the Council on Environmental Quality before the Subcomm. on Fisheries and Wildlife Conservation of the House Comm. on Merchant Marine and Fisheries*, 91st Cong., 2d Sess. 37 (1970): "[W]e are dealing with a new animal here and there is a great deal of uncertainty on the part of agencies as to just what is required . . . and these things are going to take a bit of time to get over."

24. See Library of Congress, Congressional Research Service, *Workshop on the National Environmental Policy Act prepared for the Subcomm. on Fisheries and Wildlife Conservation and Environment of the House Comm. on Merchant Marine and Fisheries*, 94th Cong., 2d Sess. 2 (Comm. Print 1976).

25. H.R. Rep. No. 316, 92d Cong., 1st Sess. 13 (1971) (emphasis in original).

26. H.R. Rep. No. 316, page 13 (emphasis in original).

27. H.R. Rep. No. 316, page 13.

28. See for example, *Calvert Cliffs Coordinating Comm. v. AEC*, 449 F.2d 1109, 1115 (D.C. Cir. 1971).

29. *Ely v. Velde*, 451 F.2d 1130, 1138-1139 (4th Cir. 1971): "With regard to NEPA, the statutory requirement of a 'detailed statement . . . on the environmental impact of the proposed action' places a heavy burden on the LEAA. To enable a court to ascertain whether there has been a genuine, not a perfunctory, compliance with NEPA, the LEAA will be required to explicate fully its course of inquiry, its analysis and its reasoning."

30. *Greene County Planning Board* v. *FPC*, 455 F.2d 412, 422 (2d Cir.), *cert. denied* 409 U.S. 849 (1972).

31. H.R. Rep. No. 316, 92d Cong., 1st Sess. 16 (1971).

32. H.R. Rep. No. 316, page 38.

33. H.R. Rep. No. 316, page 38: "For example, the Fish and Wildlife Coordination Act (16 U.S.C. 661-666c) involves agency review and comment on projects which have an impact on wildlife resources; how can NEPA be effectively worked into the Act? Could existing procedures be used to facilitate the implementation of NEPA?"

34. 325 F.Supp. 728, 739 (E.D. Ark 1972).

35. See for example, H.R. 14103, 92d Cong., 2d Sess. (1972). This bill would have amended the National Environmental Policy Act to provide a temporary partial exemption from the requirements for the issuance of environmental impact statements.

36. See for example, *Hearings before the Subcomm. on Fisheries and Wildlife Conservation and the Environment of the House Comm. on Merchant Marine and Fisheries on National Environmental Policy Act Oversight*, 94th Cong., 1st Sess. (1975).

37. See for example, General Accounting Office, *Report to the Subcommittee on Fisheries and Wildlife Conservation of the House Committee on Merchant Marine and Fisheries, Improvements Needed in Federal Efforts to Implement the National Environmental Policy Act of 1969* (May 1972).

38. See for example, Statement of Congressman Dingell in *Hearings before the Subcomm. on Fisheries and Wildlife Conservation of the House Comm. on Merchant Marine and Fisheries on Temporary Exemption from Sec. 102 Statements*, 92d Cong., 2d Sess. 28 (1972): "In perfect fairness, 102 requires really no specific amount of detail. It says you shall address yourself to certain questions, but it does not set out the amount of detail you have got to adhere to—does it?"

39. *Report to the Subcomm. on Fisheries and Wildlife Conservation and the Environment of the House Comm. on Merchant Marine and Fisheries, Workshop on the National Environmental Policy Act*, 94th Cong., 2d Sess. 18 (Comm. Print 1976).

40. *1976 Workshop Report*, page 2. See also Statement of New Jersey DOT Commissioner Alan Sagner in *1975 Oversight Hearings*, page 141: "[There is] insufficient reliance on and duplication of State environmental assessments [in the EIS process]."

41. *1976 Workshop Report*, page 2.

42. *1976 Workshop Report*, page 11.

43. *1976 Workshop Report*, page 17.

44. General Accounting Office, *Report to the Senate Committee on Environment and Public Works, The Environmental Impact Statement—It Seldom Causes Long Project Delays But Could Be More Useful If Prepared Earlier* 5 (CED-77-99 August 1977).

45. See for example, *Senate Comm. on Interior and Insular Affairs, The Council on Environmental Quality — Oversight Report*, 94th Cong., 2d Sess. 20 (Comm. Print 1976): "[T]here is a perceived need for integrating NEPA's substantive policy goals into the impact statement procedures required under 102(2)(C)."

46. Statement of CEQ Chairman Russell Peterson in *1975 Oversight Hearings*, page 208. Peterson also observed, perhaps somewhat optimistically, that "today these backlog problems have largely disappeared, and federal agencies have established procedures to integrate their EIS preparation into their planning and decisionmaking processes."

47. 3 C.F.R. § 123, 42 Fed. Reg. 26,967 (1977).

48. 40 C.F.R. § 1502.22, 51 Fed. Reg. 15,625 (1986). This provision deals with incomplete or unavailable information.
49. 40 C.F.R. § 1508.21 (1990).
50. 40 C.F.R. § 1502.7 (1990).
51. 40 C.F.R. § 1502.2(a) (1990).
52. 40 C.F.R. § 1501.2 (1990).
53. 40 C.F.R. § 1502.5 (1990).
54. 40 C.F.R. § 1500.2(c) (1990); see also 40 C.F.R. § 1502.25(a) (1990).
55. 40 C.F.R. § 1506.2(b) (1990); see also 40 C.F.R. § 1506.2(C) (1990).
56. 40 C.F.R. § 1500.2(d) (1990); see also 40 C.F.R. § 1506.6 (1990).
57. See 40 C.F.R. § 1501.7 (1990).
58. See 40 C.F.R. § 1502.21 (1990).
59. See 40 C.F.R. § 1506.3 (1990).
60. 40 C.F.R. § 1501.2(d) (1990).
61. Executive Office of the President, Council on Environmental Quality, *Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations*, 46 Fed. Reg. 18,026, 18,028 (1981).
62. See 40 C.F.R. § 1506.5(a) (1990).
63. See 40 C.F.R. § 1506.5(b) (1990).
64. See CEQ, *Forty Most Asked Questions*, page 18,031. "[T]he term 'third party contract' refers to the preparation of EISs by contractors paid for by the applicant. . . . The consulting firm is responsible to [the agency] for preparing an EIS that meets the requirements of the NEPA regulations. . . ."
65. CEQ, *Forty Most Asked Questions*, page 18,029.
66. See for example, 36 C.F.R. § 800.13 (1990). This provision relates to the section 106 National Historic Preservation Act process.
67. See for example, *Harlem Valley Transp. Ass'n* v. *Stafford*, 500 F.2d 328, 337 (2d Cir. 1974).
68. 44 Fed. Reg. 10,807 (1979).
69. S. Rep. No. 499, 94th Cong., 2d Sess. 44 (1976), *reprinted in* [1976] U.S. Code Cong. & Admin. News 14, 58.
70. S. Rep. No. 499, page 44.
71. See S. Rep. No. 499, page 44: "Of paramount concern to the Committee is the impact of rail abandonments on local communities, mostly rural in character."
72. See S. Rep. No. 499, page 44: "[T]he rail system in this Nation must not be so irreparably reduced in size that this energy and environmentally efficient mode would be incapable of meeting future transportation demands."
73. See for example, Docket No. AB-19 (Sub-No. 112), *Baltimore and Ohio Railroad Co. et al.—Abandonment—Georgetown Subdivision Located in Montgomery County, MD and the District of Columbia* (ICC Environmental Assessment), served May 15, 1986.
74. See 49 U.S.C. § 10905 (1982).
75. See 49 U.S.C. § 10905(c) (1982).
76. See 49 U.S.C. § 10905(d) (1982).
77. See 49 U.S.C. § 10905(e) (1982).

78. See *Chicago and North Western Transp. Co.* v. *U.S.*, 678 F.2d 665, 666 (7th Cir. 1982).

79. 16 U.S.C. § 1247(d) *as amended* Pub. L. 98-11, § 208, 97 Stat. 48 (1983).

80. 16 U.S.C. § 1247(d).

81. See 49 C.F.R. § 1152.29 (1989).

82. See *National Wildlife Federation* v. *ICC*, 850 F.2d 694, 702 (D.C. Cir. 1988).

83. See H.R. Rep. No. 28, 98th Cong., 1st Sess. 8-9 (1983), *reprinted in* [1983] U.S. Code Cong. & Admin. News 112, 115.

84. See S. Rep. No. 499, page 116.

85. 49 U.S.C. § 10906 (1982).

86. See 49 C.F.R. § 1152.28 (1989).

87. See *Conn. Trust for Historic Preservation* v. *ICC*, 841 F.2d 479, 483 (2d Cir. 1988).

88. Title I, 101(a)(5), Regional Rail Reorganization Act of 1973, Pub. L. No. 93-236, 87 Stat. 986 (1974).

89. See for example, *Illinois Commerce Com'n* v. *ICC*, 848 F.2d 1246, 1262 (D.C. Cir. 1988): Congress believed that even state governments needed "at least four months' advance notice about potential abandonments in order to fulfill their role of protecting local economic and transportation needs." (Mikva, Judge, who concurred in part and dissented in part).

90. 49 U.S.C. § 10904(e)(2) (1982).

91. 49 U.S.C. § 10904(e)(3) (1982).

92. 49 U.S.C. § 10904(a)(A)—(B) (1982).

93. 49 U.S.C. § 10904(a)(2)(C) (1982).

94. 49 U.S.C. § 10904(a)(3)(A)—(D) (1982).

95. 49 U.S.C. § 10101a(2) (1982).

96. 49 U.S.C. § 10904(b) (1982).

97. 49 U.S.C. § 10904(c)(1) (1982).

98. 49 U.S.C. § 10904(c)(2)—(3) (1982).

99. See *Abandonment of R. Lines & Discontinuance of Serv.*, 365 I.C.C. 249, 252 (1981).

100. See *Jones* v. *District of Columbia Redevelopment Land Agency*, 499 F.2d 502, 512 (D.C. Cir. 1974), *cert. denied*, 423 U.S. 937 (1975).

101. See for example, Docket No. AB-102 (Sub-No. 13), *Missouri-Kansas-Texas Railroad Company—Abandonment—In St. Charles, Warren, Montgomery, Callaway, Boone, Howard, Cooper and Pettis Counties, MO* (not printed) served March 16, 1987.

102. See 36 C.F.R. Part 800 (1989).

103. See 49 C.F.R. § 1105.7(c) (1989).

104. 49 C.F.R. § 1105.3 (1989).

105. *Abandonment of R. Lines*, page 250.

106. *Revision of Abandonment Regulations*, 367 I.C.C. 831, 841 (1983).

107. *Revision of Abandonment Regulations*, page 841.

108. See Letter of T. F. King, Director, Office of Cultural Resource Preservation, ACHP to W. R. Southard, Director, Office of Transportation Analysis, ICC dated January 21, 1987, transmitting PMOA approved by ACHP for execution by ICC.

The OTA director is responsible for administration of ICC's NEPA rules. See 49 C.F.R. § 1105.2 (1989).

109. See 49 C.F.R. § 1152.21 (1989).

110. See 49 C.F.R. § 1105.6(b)(1) (1989).

111. See 40 C.F.R. § 1506.5(b) (1990).

112. See CEQ, *Forty Most Asked Questions*, page 18,037.

113. Compare *Flint Ridge Development Co.* v. *Scenic Rivers Association*, 426 U.S. 776, 787-88 (1976) with *Jones* v. *Gordon*, 792 F.2d 821, 826 (9th Cir. 1986).

114. See Docket No. AB-19 (Sub-No. 112), *Baltimore and Ohio Railroad Co.—Abandonment of the Georgetown Subdiv. Located in Montgomery County, Md. and the District of Columbia*, served May 27, 1986.

115. 40 C.F.R. § 1508.9(b) (1990).

116. See *Northwest Coal. for Altern. to Pesticides* v. *Lyng*, 844 F.2d 588, 591 (9th Cir. 1988).

117. See CEQ, *Forty Most Asked Questions*, page 18,027.

118. See for example, *Public Serv. Co.* v. *U.S. Nuclear Regulatory Com'n*, 582 F.2d 77, 81 (1st Cir. 1978). See also *Robertson* v. *Methow Valley Citizens Council*, 109 S.Ct. 1835, 1846 (1989): Consistent with the "requirement that an EIS contain a detailed discussion of possible mitigation measures [which] flows from both the language of the Act and, more expressly, from CEQ's implementing regulations . . . the EIS will discuss the extent to which adverse effects can be avoided."

119. *Trout Unlimited* v. *Morton*, 509 F.2d 1276, 1286 (9th Cir. 1974).

120. See CEQ, *Forty Most Asked Questions*, page 18,027.

121. Executive Office of the President, Council on Environmental Quality, *Environmental Quality 1986*, 17th Annual Report (Washington, D.C.: U.S. Government Printing Office, 1988), page 236.

122. See CEQ, *Forty Most Asked Questions*, page 18,027: "An alternative that is outside the legal jurisdiction of the lead agency must still be analyzed . . . *if it is reasonable*." (emphasis supplied).

123. See 40 C.F.R. § 1508.23 (1990).

124. S. Rep. No. 499, page 44.

125. See Docket No. AB-32 (Sub-No. 32), *Report Concerning the Effect of Abandonment of a Segment of the Hillsboro Branch, Boston and Maine Railroad, Upon the Historical Integrity of the Monadnock Paper Mills, Bennington, New Hampshire* 4 (served Jan. 22, 1986).

126. *Monadnock Paper Mills Report*, pages 1-2.

127. *Monadnock Paper Mills Report*, page 11.

128. See Finance Docket No. 31701, *Milford—Bennington Railroad Company, Inc.—Acquisition—Boston and Maine Corporation Hillsboro Branch*, filed June 21, 1990.

129. See Interstate Commerce Commission, *1989 Annual Report*, 103rd Annual Report (Wasgington, D.C.: U.S. Government Printing Office, 1990), page 118.

130. Compare 49 U.S.C. § 10505 with 49 U.S.C. § 10904 and 49 U.S.C. § 10327 (1982).

131. See *Illinois Commerce Com'n* v. *ICC*, 848 F.2d 1246, 1259-60 (D.C. Cir. 1988).

132. See 49 C.F.R. § 1152.50(d)(3). In Exemption of Out-of-Service Rail Lines, 5 I.C.C.2d 377, 380 (1989), the ICC declared that it was "unwilling to expand our notice requirements for the exemption beyond Federal Register publication,"

currently provided within 20 days of the filing of a notice of abandonment exemption. See also *Illinois Commerce Com'n* v. *ICC*, page 1260.

133. ICC, consistent with the opinion in *Illinois Commerce Com'n* v. *ICC*, completes the environmental process prior to the *effectiveness* of any abandonment exemption decision. But see *Sierra Club* v. *Marsh*, 872 F.2d 497, 500 (1st Cir. 1989): "*When a decision to which NEPA obligations attach is made without the informed environmental consideration that NEPA requires, the harm that NEPA intends to prevent has been suffered.*" (emphasis in original).

134. S. Rep. No. 121, 101st Cong., 1st Sess. 122 (1989): The Committee is concerned that the ICC has tended to adopt narrow interpretations of such statutes as the 1983 Rail Banking Act. . . . ICC should consider and adopt new policies and procedures to foster the preservation of rail corridors for future transportation and alternative uses. . . . The Committee is interested in protecting existing rail corridors, especially those abandoned (or at risk) ones which may be lost to alternative uses.

135. See *Illinois Commerce Com'n* v. *ICC*.

136. National League of Cities, Policy Item No. 5(c), approved Dec. 7, 1988.

137. Caldwell, L., "The National Environmental Policy Act: retrospect and prospect," 6 Envirn. L. Rptr. 50,030 (December 1976).

138. 42 U.S.C. § 4331(b)(4) (1982).

139. 16 U.S.C. § 470f (West 1985).

140. 16 U.S.C. § 470f (West 1985).

141. See 36 C.F.R. Part 800 (1990).

142. *Preservation Coalition, Inc.* v. *Pierce*, 667 F.2d 851, 858-859 and note 2 (9th Cir. 1982): "Of course, Advisory Council decisions are of greater weight for NHPA purposes, where their role is prescribed by statute, than for NEPA purposes."

143. *Preservation Coalition, Inc.* v. *Pierce*, page 859.

144. *Morris Cty. Trust for Historic Preserv.* v. *Pierce*, 714 F.2d 271, 282 (3rd Cir. 1983).

145. H.R. Rep. No. 590, 95th Cong., 1st Sess. 89 (1977) 89; *reprinted in* [1978] U.S. Code Cong. & Admin. News at 1450, 1496.

146. H.R. Rep. No. 590, page 149.

147. H.R. Rep. No. 590, page 52.

148. H.R. Rep. No. 599, page 52.

149. See 43 U.S.C. §§ 1331(p), 1344(b)(3), 1346(a) (by implication), and 1351 (e)-(h), and (k) (West 1986).

150. *Village of False Pass* v. *Clark*, 733 F.2d 605, 609 (9th Cir. 1984).

151. H.R. Rep. No. 590, page 122.

152. *Secretary of the Interior* v. *California*, 464 U.S. 312, 337 (1984).

153. 43 U.S.C. § 1346(a)(2) (West 1986).

154. See 43 U.S.C. § 1346(c) (West 1986).

155. H.R. Rep. No. 590, page 167.

156. H.R. Rep. No. 590, page 167.

157. See *Village of False Pass* v. *Clark*, 733 F.2d 605, 609 (9th Cir. 1984).

158. *Village of False Pass*, page 609.

159. 16 U.S.C. § 1536(a)(2) (West 1985).

160. 50 C.F.R. § 402.02 (1989). The biological assessment "may be consolidated with interagency cooperation procedures required by other statutes, such as the National Environmental Policy Act." 50 C.F.R. § 402.06(a) (1989).

161. 50 C.F.R. § 402.14(g)(8) (1989).

162. 50 C.F.R. § 402.02 (1989).

163. 50 C.F.R. § 402.15(a) (1989).

164. *Kleppe* v. *Sierra Club*, 427 U.S. 390, 410 n. 21 (1976).

165. *North Slope Borough* v. *Andrus*, 486 F.Supp. 332, 345 (D.D.C. 1979), *aff'd in part, rev'd in part on other grounds*, 642 F.2d 589 (D.C. Cir. 1980).

166. See generally U.S. Department of the Interior, Minerals Management Service, *Protected Species Workshop* (Portland, ME: MMS, 1990).

167. 43 U.S.C. § 1346 (West 1986).

168. General Accounting Office, *Offshore Oil and Gas: Environmental Studies Program Meets Most User Needs but Changes Needed*, GAO/RCED-88-104 (Washington, D.C.: GAO, 1988), page 11.

169. *GAO*, page 11.

170. *Conservation Law Foundation* v. *Watt*, 560 F.Supp. 561, 572 (D.Mass. 1983), *aff'd* 716 F.2d 946 (1st Cir. 1983).

171. 16 U.S.C. § 1536(d) (West 1985).

172. H. Con. Rep. No. 697, 96th Cong. 1st Sess. 12 (1979), *reprinted in* [1979] U.S. Code Cong. & Admin. News 2572, 2576.

173. H. Con Rep. No. 697, page 12. Formal consultation concludes within 90 days after initiation unless extended by mutual agreement. See 50 C.F.R. § 402.14(e) (1989).

174. 50 C.F.R. § 402.14(k) (1989).

175. See 50 C.F.R. § 402.14(k)(1)—(5) (1989).

176. See for example, *North Slope Borough* v. *Andrus*, 642 F.2d 589, 609 (D.C. Cir. 1980): This opinion discusses "'uncertainty' as a problem an EIS must reckon with" apart from section 7 ESA requirements in OCS lease sale decisions.

177. 40 C.F.R. § 1506.1(a) (1990).

178. See for example, *Named Individual Members of the San Antonio Conservation Society* v. *Texas Highway Department*, 446 F.2d 1013, 1027 (5th Cir. 1971), *cert. denied*, 701 U.S. 933 (1972).

179. 40 C.F.R. § 1506.1(c)(1)—(2) (1990). Additionally, such interim action must not "prejudice the ultimate decision on the program. Interim action prejudices the ultimate decision on the program when it tends to determine subsequent development or limit alternatives." 40 C.F.R. § 1506.1(c)(3) (1990). See also *Commonwealth of Massachusetts* v. *Watt*, 716 F.2d 946, 952-53 (1st Cir. 1983).

180. See for example, *North Slope Borough* v. *Andrus*, 486 F.Supp. 332, 346-48 (D.D.C. 1979), *aff'd in part, rev'd in part on other grounds*, 642 F.2d 589, 605-06 (D.C. Cir. 1980).

181. See Staff of Subcomm. on Science, Research, and Development of the House Comm. on Science and Astronautics, 89th Cong., 2d Sess., *Report on Environmental Pollution* 5 (Comm. Print 1966).

182. See *Report on Environmental Pollution*, page 5.

183. *Robertson* v. *Methow Valley Citizens Council*, 109 S.Ct. 1835, 1849 (1989).

184. *Robertson*, page 1848, citing 40 C.F.R. § 1502.22.

185. See e.g., 40 C.F.R. § 1508.27 (1990).

186. *Marsh* v. *Oregon Natural Resources Council*, 109 S.Ct. 1851, 1859 (1989).

187. Statement of the President on Outer Continental Shelf Oil and Gas Development, 26 Weekly Comp. Pres. Doc. 1006 (June 26, 1990) (emphasis in original).

188. Presidential statement, page 1007 (emphasis in original).

189. Jackson, H., "Overview on Environmental Problems," Lecture at the University of Pennsylvania Engineering School in Philadelphia (Unpublished manuscript, March 31, 1971) (emphasis supplied).

190. U.S. Environmental Protection Agency, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection* (Washington, D.C.: EPA, Science Advisory Board, September 1990), page 1.

191. EPA, *Reducing Risk*, pages 1-2.

192. *Report on Managing the Environment*, page 17.

193. EPA, *Reducing Risk*, page 9: "For example, as the extent and quality of saltwater estuaries decline, both human health and local economies can suffer. As soils erode, forests, farmlands, and waterways can become less productive. And while the loss of species may not be noticed immediately, over time the decline in genetic diversity has implications for the future health of the human race."

194. S. Rep. No. 296, 91st Cong., 1st Sess. 5 (1969).

195. 110 S. Ct. 3177 (1990).

196. The motion was filed pursuant to Rule 56 of the Federal Rules of Civil Procedure (FRCP). The plaintiffs had survived an earlier motion to dismiss under FRCP 12(b).

197. *National Wildlife Federation* v. *Burford*, 699 F. Supp. 327 (D.D.C. 1988).

198. *National Wildlife Federation* v. *Burford*, 878 F.2d 422 (D.C. Cir. 1989).

199. 915 F.2d 1308 (9th Cir. 1990).

200. 36 C.F.R. §§ 223.113, 223.116(a)(5).

201. 914 F.2d 179 (9th Cir. 1990).

202. Pub. L. No. 101-121, 103 Stat. 743 (1989). This section denies judicial review of Forest Service plans on the sole basis that the plans, in their entirety, are outdated.

203. 914 F.2d at 181.

204. 914 F.2d at 182.

205. 914 F.2d 1311 (9th Cir. 1990).

206. Pub. L. No. 101-121, 103 Stat. 701, 754-50 (1989).

207. Pub. L. No. 101-121, 103 Stat. 701, 754-50, section 318(b)(6)(A) (emphasis added).

208 915 F.2d 167 (5th Cir. 1990).

209. 915 F.2d at 170.

210. 916 F.2d 13 (D.C. Cir. 1990).

211. 33 U.S.C. § 1344.

212. As a preliminary matter, the court also examined the plaintiffs' claim that Maryland improperly segmented the rail project to avoid preparing NEPA documents on the 22.5-mile segment. The court stated that "[t]he segmentation cases are distinguishable because they involve the question of whether a *federal* project has been illegally segmented to avoid compliance with NEPA." 916 F.2d at 16 n. 4 (emphasis in original).

213. 916 F.2d at 16.

214. 916 F.2d at 18.

215. 916 F.2d at 18-19.

216. 916 F.2d at 20.

217. 912 F.2d 1471 (D.C. Cir. 1990).

218. 912 F.2d at 1477 (emphasis in original).

219. See 40 C.F.R. § 1508.25(a).

220. See 40 C.F.R. §§ 1508.7, 1508.8, and 1508.25(c). See also *Fritiofson* v. *Alexander*, 772 F.2d 1225 (5th Cir. 1985).

221. See 40 C.F.R. § 1508.23.

222. 40 C.F.R. § 1508.7.

223. 911 F.2d 499 (11th Cir. 1990).

224. 900 F.2d 1091 (7th Cir. 1990).

225. 42 U.S.C. § 9613(h).

226. See also *Werlein* v. *United States*, 746 F. Supp. 887 (D. Minn. 1990).

227. 737 F.Supp. 277 (S.D.N.Y. 1990).

228. 742 F.Supp. 1377 (N.D. Ill. 1990).

229. 747 F.Supp. 1094 (D.Vt. 1990).

230. 747 F.Supp. at 1100 (citations omitted).

231. 731 F.Supp. 530 (D.D.C. 1990).

232. 731 F.Supp. at 532.

233. 731 F.Supp. at 532-33.

234. The United States Court of Appeals for the District of Columbia Circuit was also asked to address global warming in the context of a NEPA review. In a per curiam opinion on several consolidated cases captioned *City of Los Angeles and City of New York* v. *National Highway Traffic Safety Administration*, 912 F.2d 478 (D.C. Cir. 1990), the court found that petitioner, Natural Resources Defense Council, had standing under NEPA to challenge defendant's Corporate Average Fuel Economy (CAFE) standards for model year 1989 on the grounds that those standards could contribute to global warming that would adversely affect its members. On the merits, however, the court could not conclude that the agency had acted arbitrarily or capriciously in deciding not to prepare an EIS before issuing the CAFE standards.

235. 748 F. Supp. 749 (D. HI. 1990).

236. The court had earlier denied plaintiffs' motion for a temporary restraining order.

237. 748 F.Supp. at 757.

238. 748 F.Supp. at 759, citing NEPA, 42 USC 4332(F).

239. 748 F.Supp. at 759 (emphasis in original).

240. 748 F.Supp. at 759 (emphasis in original).

241. 748 F.Supp. at 760.

242. 748 F.Supp. at 763.

243. 748 F.Supp. at 762 (emphasis in original).

PART II

ENVIRONMENTAL DATA AND TRENDS

EXECUTIVE OFFICE OF THE PRESIDENT OF THE UNITED STATES
COUNCIL ON ENVIRONMENTAL QUALITY

Aerial photography is among the techniques used to monitor and measure environmental change. The National Environmental Policy Act of 1969 states:

> ***It shall be the duty and function of the Council . . . to gather timely and authoritative information concerning the conditions and trends in the quality of the environment both current and prospective, to analyze and interpret such information . . . and to report at least once each year to the President on the state and condition of the environment . . .***

PART II

ENVIRONMENTAL DATA AND TRENDS

The National Environmental Policy Act of 1969 requires the Council on Environmental Quality (CEQ) to report annually on the status and condition of the environment, on current and foreseeable trends in the quality, management, and utilization of the environment; and on the effects of environmental trends (see Appendix). In 1989 CEQ published the third edition of *Environmental Trends*, a source book of 367 tables and graphics selected by an interagency advisory committee as indicators of environmental quality. *Environmental Trends* is therefore a useful background reference for the data presented on the following pages.

This part of the 1990 CEQ annual report contains updated data for selected environmental indicators. The following objectives influenced the selection of indicators:

- Maintaining a standard set of useful environmental reference data,
- Adding tables of newly available data, and
- Highlighting data on current environmental concerns.

Tables and figures are based on the most recently available data, but in some cases a delay of one or more years exists between data collection and final reporting. Data represent national conditions unless otherwise indicated. Because national data may not reflect pertinent geographic variations, some statistics are presented for regional, state, and local areas. Sources listed with the tables may be consulted for additional information regarding the statistical properties or the interpretation of data.

Explanatory highlights are included to help the reader understand the data presented. Graphs illustrate trends of selected data; however, caution is advised in inferring significance of trends or relationships between trends. Often data covering the past several decades are presented graphically in this report with data for a longer time series presented within the tables or available from the source.

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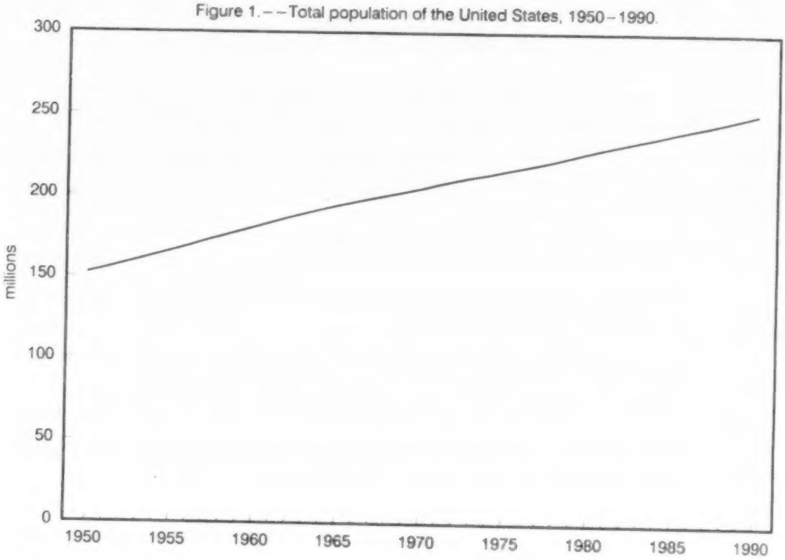
Population

Human populations and economic development affect environmental quality, as human use of natural resources changes the environment. The United States has comprehensive demographic data that define temporal and spatial patterns and are useful in understanding trends in environmental quality.

Highlights include the following trends:

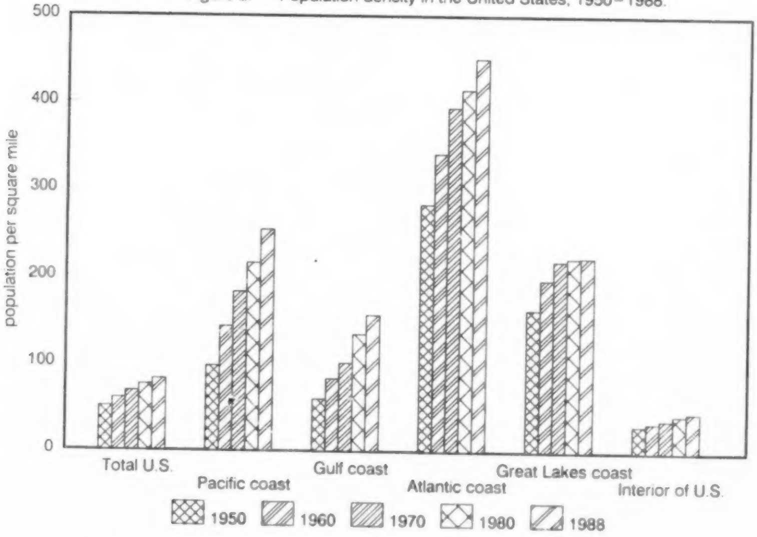
- The U. S. population has grown at an annual rate of 1 percent for the past decade.
- Population density is greatest in coastal areas, where rates of increase have been greater than in interior areas.
- The percentage of the U.S. population living in suburban areas has nearly doubled, to 45 percent, since 1950.

Figure 1.--Total population of the United States, 1950-1990.



Source: See Table 1.

Figure 2.--Population density in the United States, 1950-1988.



Source: See Table 7.

Table 1.–Total population, including armed forces overseas, 1900-1990.

(millions)

Year	Population	Year	Population	Year	Population
1900	76.09	1931	124.15	1962	186.54
1901	77.58	1932	124.95	1963	189.24
1902	79.16	1933	125.69	1964	191.89
1903	80.63	1934	126.49	1965	194.30
1904	82.17	1935	127.36	1966	196.56
1905	83.82	1936	128.18	1967	198.71
1906	85.45	1937	128.96	1968	200.71
1907	87.01	1938	129.97	1969	202.68
1908	88.71	1939	131.03	1970	205.05
1909	90.49	1940	132.59	1971	207.66
1910	92.41	1941	133.89	1972	209.90
1911	93.86	1942	135.36	1973	211.91
1912	95.34	1943	137.25	1974	213.85
1913	97.23	1944	138.92	1975	215.97
1914	99.11	1945	140.47	1976	218.04
1915	100.55	1946	141.94	1977	220.24
1916	101.96	1947	144.70	1978	222.59
1917	103.41	1948	147.21	1979	225.06
1918	104.55	1949	149.77	1980	227.76
1919	105.06	1950	152.27	1981	230.14
1920	106.46	1951	154.88	1982	232.52
1921	108.54	1952	157.55	1983	234.80
1922	110.05	1953	160.18	1984	237.00
1923	111.95	1954	163.03	1985	239.28
1924	114.11	1955	165.93	1986	241.63
1925	115.83	1956	168.90	1987	243.94
1926	117.40	1957	171.98	1988	246.31
1927	119.04	1958	174.88	1989	248.76
1928	120.51	1959	177.83	1990	250.39
1929	121.77	1960	180.67		
1930	123.19	1961	183.69		

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Population Estimates, by Age, Sex, and Race, and Hispanic Origin: 1989. Current Population Reports, series P-25, no. 1057, and earlier reports in this series. Washington, D.C.

Notes: Annual population estimate as of July 1. Data for 1990 are projections.

Table 2.--Population growth rate, 1901-1989.

(percent change)

Year	Growth rate	Year	Growth rate	Year	Growth rate
1901	2.0	1931	0.7	1961	1.6
1902	2.0	1932	0.6	1962	1.5
1903	1.9	1933	0.6	1963	1.4
1904	1.9	1934	0.7	1964	1.3
1905	2.0	1935	0.7	1965	1.2
1906	1.9	1936	0.6	1966	1.1
1907	1.8	1937	0.7	1967	1.1
1908	2.0	1938	0.8	1968	1.0
1909	2.0	1939	0.8	1969	1.0
1910	2.1	1940	0.9	1970	1.3
1911	1.6	1941	1.0	1971	1.2
1912	1.6	1942	1.3	1972	1.0
1913	2.0	1943	1.3	1973	0.9
1914	1.9	1944	1.2	1974	0.9
1915	1.4	1945	1.0	1975	1.0
1916	1.4	1946	1.5	1976	1.0
1917	1.4	1947	1.8	1977	1.0
1918	1.1	1948	1.7	1978	1.1
1919	0.5	1949	1.7	1979	1.2
1920	1.3	1950	1.7	1980	1.1
1921	2.0	1951	1.7	1981	1.0
1922	1.4	1952	1.7	1982	1.0
1923	1.7	1953	1.7	1983	1.0
1924	1.9	1954	1.8	1984	0.9
1925	1.5	1955	1.8	1985	1.0
1926	1.4	1956	1.8	1986	1.0
1927	1.4	1957	1.7	1987	1.0
1928	1.2	1958	1.7	1988	1.0
1929	1.0	1959	1.7	1989	1.0
1930	0.9	1960	1.6		

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Population Estimates, by Age, Sex, and Race, and Hispanic Origin: 1989. Current Population Reports, series P-25, no. 1057, and earlier reports in this series. Washington, D.C.

Note: Annual population estimate as of July 1.

Table 3.--Components of total population change, 1940-1989.

(millions)

Year	Births	Deaths	Net civilian immigration	Net change
1940	2.570	1.432	0.077	1.221
1945	2.873	1.549	0.162	1.462
1950	3.645	1.468	0.299	2.486
1955	4.128	1.537	0.337	2.925
1960	4.307	1.708	0.328	2.901
1965	3.801	1.830	0.373	2.315
1970	3.739	1.927	0.438	2.617
1975	3.144	1.894	0.449	2.165
1980	3.612	1.990	0.845	2.582
1985	3.761	2.087	0.650	2.325
1989	3.977	2.155	0.682	2.505

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Population Estimates, by Age, Sex, and Race, and Hispanic Origin: 1989. Current Population Reports, series P-25, no. 1057, and earlier reports in this series. Washington, D.C.

Note: Annual population estimate as of July 1.

Table 4.--Age structure of the population, including armed forces overseas, 1940-1989.

(millions)

Year	Population, by age class, in years							
	< 5	5-14	15-24	25-34	35-44	45-54	55-64	> 64
1940	10.6	22.3	24.0	21.5	18.4	15.6	10.7	9.0
1950	16.3	24.5	22.3	23.9	21.6	17.4	13.4	12.4
1960	20.3	35.7	24.6	22.9	24.2	20.6	15.6	16.7
1970	17.2	40.7	36.5	25.3	23.1	23.3	18.7	20.1
1980	16.5	34.8	42.7	37.6	25.9	22.8	21.8	25.7
1985	18.0	33.9	39.6	42.1	31.8	22.6	22.3	28.5
1989	18.8	35.2	36.7	44.1	36.6	24.9	21.6	31.0

Source: U.S. Department of Commerce, Bureau of the Census. 1975. Historical Statistics of the United States: Colonial Times to 1970, series A 30-37. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. U.S. Population Estimates, by Age, Sex, and Race, and Hispanic Origin: 1989. Current Population Reports, series P-25, no. 1057, and earlier reports in this series. Washington, D.C.

Note: Annual population estimate as of July 1.

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Table 5.--Metropolitan and nonmetropolitan population patterns, 1950-1986.

(percent of total population)

Year	Inside central cities of MSAs	Suburbs outside MSAs	Nonmetropolitan areas
1950	32.80	23.30	43.90
1960	32.30	30.60	37.10
1970	31.40	37.20	31.40
1980	30.00	44.80	25.20
1986	31.65	45.05	23.30

Source: U.S. Department of Commerce, Bureau of the Census. Patterns of Metropolitan Area and County Population Growth: 1980 to 1987. Current Population Reports, series P-25, no. 1039, and earlier reports in this series. Washington, D.C.

Note: MSAs=Metropolitan Statistical Areas.

Table 6.--Net population migration, by region, 1960-1987.

(gains and losses, in millions)

Region	1960-1970	1970-1980	1980-1987
Northeast	0.375	-2.888	-0.366
Midwest	-0.752	-2.703	-2.148
South	0.592	5.992	4.309
West	2.854	4.115	3.074

Source: U.S. Department of Commerce, Bureau of the Census. Patterns of Metropolitan Area and County Population Growth: 1980 to 1987. Current Population Reports, series P-25, no. 1039, and earlier reports in this series. Washington, D.C.

Table 7.--Population density, 1940-1988.

(population per square mile)

Year	Total conterminous United States	Counties in coastal regions				Interior of U.S.
		Pacific	Gulf	Atlantic	Great Lakes	
1940	44.4	64.1	44.8	244.4	140.9	28.5
1950	50.8	97.6	59.8	283.3	162.9	30.9
1960	60.2	142.7	83.1	341.6	197.3	34.3
1970	68.2	182.5	101.1	394.4	219.1	37.6
1980	76.0	215.8	134.1	414.9	222.4	42.8
1985	79.1	231.5	149.3	429.7	221.4	44.6
1988	82.4	254.2	156.4	450.8	223.1	45.9

Source: U.S. Department of Commerce, Bureau of the Census. Statistical Abstract of the United States, annual. Washington, D.C.

Note: Coastal area includes 611 counties and independent cities which are entirely or substantially within 50 miles of the U.S. coast.

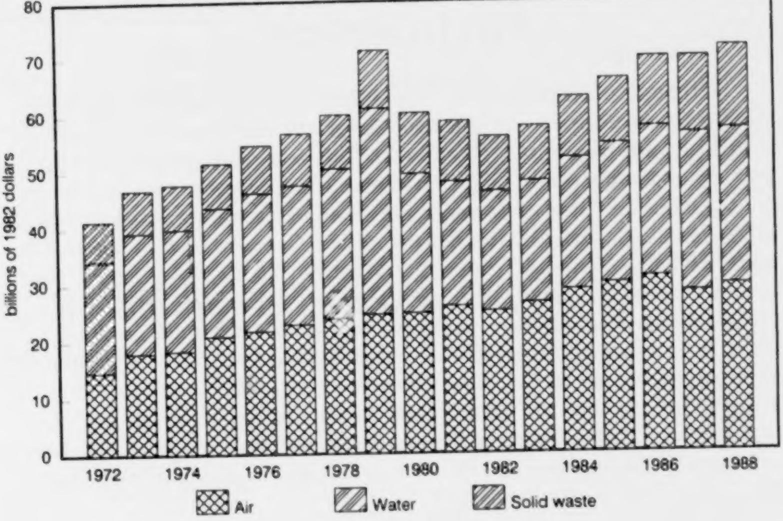
The Economy and the Environment

Although a wealth of data is available on economic activity, determining the economic costs and benefits of environmental laws remains a difficult task (see Part I, Chapter 2). This section highlights available data for expenditures on pollution abatement. Among the major sources for statistics on these costs are the Bureau of Economic Analysis (used in Tables 9, 10, and 11), the Bureau of the Census (used in Table 12), and the Environmental Protection Agency. While the primary data source may be the same, each agency report incorporates different adjustments or uses different bookkeeping procedures, such as those related to interest and depreciation costs. As a result, the estimates of 1990 expenditures on pollution abatement range from $85.9 billion to $115 billion and are all valid estimates that reflect different economic perspectives. Therefore data from different tables may not be directly comparable and readers should consult the sources to determine if data are appropriate for their needs.

Highlights include the following trends:

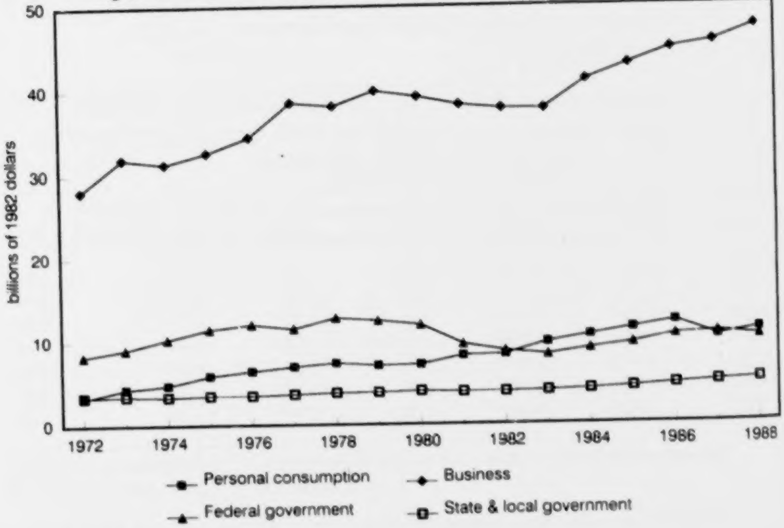
- Expenditures for pollution abatement constitute approximately 2 percent of the U.S. gross national product (GNP).
- The business sector accounts for most expenditures for pollution abatement; however, the proportion of personal expenditures to purchase and operate motor vehicle emission abatement devices has increased since the early 1970s.
- Operating expenditures for pollution abatement for some industries have been increasing, while expenditures in other industries leveled off in the 1980s.
- State and local government expenditures for environmental purposes have increased markedly.

Figure 3.--Expenditures for pollution abatement, by type of pollution, 1972-1988.



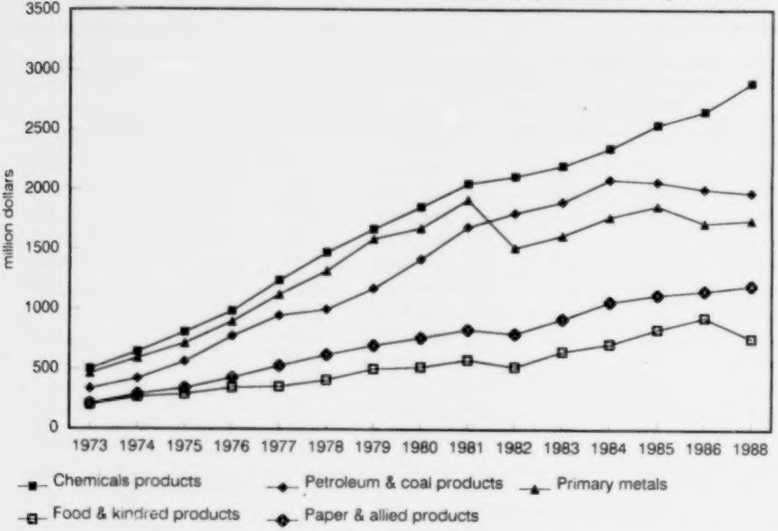
Source: See Table 10.

Figure 4.--Expenditures for pollution abatement and control, by sector, 1972-1988.



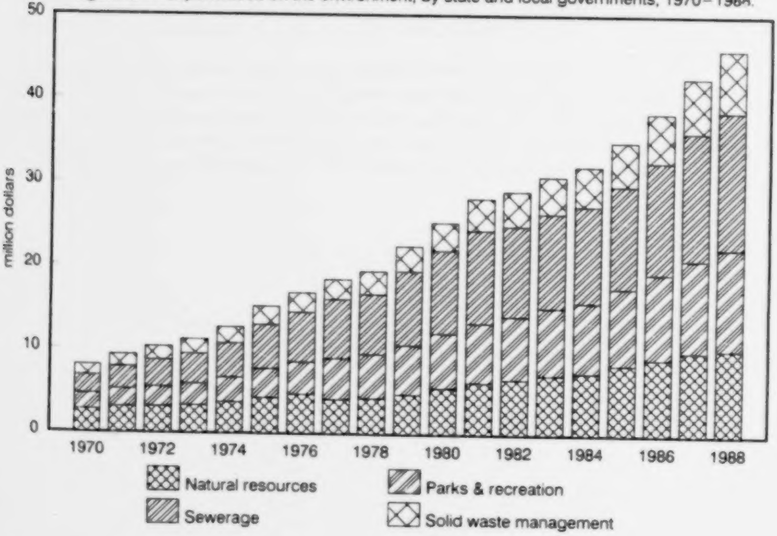
Source: See Table 11.

Figure 5.--Operating expenditures for pollution abatement, by selected industry, 1973-1988.



Source: See Table 12.

Figure 6.--Expenditures on the environment, by state and local governments, 1970-1988.



Source: See Table 13.

Table 8.--Gross national product, 1929-1990.

(billions of dollars)

Year	Current dollars	1982 dollars
1929	103.9	709.6
1935	072.8	580.2
1940	100.4	772.9
1945	213.4	1,354.8
1950	288.3	1,203.7
1955	405.9	1,494.9
1960	515.3	1,665.3
1965	705.1	2,087.6
1970	1,015.5	2,416.2
1975	1,598.4	2,695.0
1980	2,732.0	3,187.1
1985	4,014.9	3,618.7
1989	5,200.8	4,117.7
1990	5,463.0	4,155.8

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business, quarterly issues. Washington, D.C.

Executive Office of the President, Council on Economic Advisers. 1991 Economic Report. Washington, D.C.

Table 9.--Expenditures for pollution abatement and control, 1972-1988.

[billions of current and constant (1982) dollars]

	Total		Pollution abatement		Regulation & monitoring		Research & development	
Year	Current	Constant	Current	Constant	Current	Constant	Current	Constant
1972	18.1	43.0	16.7	40.3	0.4	0.8	0.8	1.9
1973	21.8	48.8	20.4	45.8	0.5	1.0	0.9	2.0
1974	25.6	49.8	24.0	46.7	0.6	1.1	1.0	2.0
1975	30.2	53.5	28.4	50.4	0.7	1.1	1.1	2.0
1976	33.9	56.5	31.9	53.2	0.7	1.2	1.3	2.2
1977	37.6	58.7	35.3	55.1	0.8	1.2	1.5	2.3
1978	42.7	62.1	40.1	58.3	1.0	1.3	1.7	2.4
1979	48.7	63.3	45.9	59.5	1.1	1.4	1.8	2.4
1980	53.5	62.1	50.5	58.4	1.3	1.5	1.8	2.1
1981	57.5	60.3	54.3	57.0	1.4	1.5	1.8	1.9
1982	57.7	57.7	54.5	54.5	1.4	1.4	1.8	1.8
1983	61.8	60.0	58.1	56.5	1.4	1.3	2.3	2.3
1984	68.9	64.7	65.2	61.3	1.4	1.2	2.3	2.2
1985	74.6	68.1	71.0	64.9	1.3	1.1	2.4	2.2
1986	78.7	71.3	74.6	68.2	1.5	1.3	2.6	2.3
1987	81.1	71.4	76.9	67.8	1.5	1.2	2.7	2.3
1988	85.9	73.7	81.5	70.0	1.7	1.3	2.8	2.3

Fraber, K.D. & G.L. Rutledge. 1986. Pollution Abatement and Control Expenditures. Survey of Current Business, table 9, pp. 100-103 (July). U.S. Department of Commerce, Bureau of Economic Analysis. Washington, D.C.

Bratton, D.M. & G.L. Rutledge. 1990. Pollution Abatement and Control Expenditures, 1985-88. Survey of Current Business, table 7, pp. 36-37 (November). U.S. Department of Commerce, Bureau of Economic Analysis. Washington, D.C.

Notes: Pollution abatement and control (PAC) spending is for goods and services that U.S. residents use to produce cleaner air and water and to dispose of solid waste. PAC spending consists of expenditures associated with pollution abatement, regulation and monitoring, and research and development. Data do not include interest costs. Totals may not agree with detail because of independent rounding.

Table 10.–Expenditures for pollution abatement, by type of pollution, 1972-1988.

[billions of current and constant (1982) dollars]

Year	Air		Water		Solid waste	
	Current	Constant	Current	Constant	Current	Constant
1972	5.6	14.6	8.5	19.7	3.3	7.1
1973	7.3	17.9	9.7	21.3	3.7	7.6
1974	9.1	18.3	11.2	21.5	4.3	7.9
1975	11.4	20.8	13.0	22.8	4.7	7.9
1976	12.6	21.7	14.9	24.5	5.2	8.4
1977	14.1	22.8	16.1	24.7	6.0	9.1
1978	15.7	23.8	19.0	26.6	6.5	9.5
1979	18.6	24.5	20.6	36.5	7.8	10.2
1980	21.9	24.7	21.3	24.7	8.8	10.7
1981	25.1	25.9	20.8	22.0	10.0	10.7
1982	25.0	25.0	21.2	21.2	9.6	9.6
1983	26.6	26.4	22.4	21.5	10.2	9.7
1984	29.6	28.6	25.2	23.3	11.8	10.8
1985	31.2	29.7	27.6	24.7	13.1	11.5
1986	31.2	30.8	29.7	26.5	14.7	12.3
1987	29.7	28.1	32.1	28.0	16.6	13.5
1988	31.9	29.3	32.2	27.5	18.8	14.6

Fraber, K.D. & G.L. Rutledge. 1986. Pollution Abatement and Control Expenditures. Survey of Current Business, table 9, pp. 100-103 (July). U.S. Department of Commerce, Bureau of Economic Analysis. Washington, D.C.

Bratton, D.M. & G.L. Rutledge. 1990. Pollution Abatement and Control Expenditures, 1985-88. Survey of Current Business, table 7, pp. 36-37 (November). U.S. Department of Commerce, Bureau of Economic Analysis. Washington, D.C.

Notes: Expenditures are attributed to the sector that performs the air or water pollution abatement or solid waste collection and disposal. Data do not include interest costs. Totals may not agree with detail because of independent rounding.

Table 11.–Expenditures for pollution abatement, by sector, 1972-1988.

[billions of constant (1982) dollars]

	Pollution abatement					Regulation & monitoring		Research & development		
	Private		Government							
Year	Pers'l	Bus.	Fed.	State	Other	Fed.	State	Prv't	Fed.	State
1972	3.26	31.50	0.35	2.85	7.07	0.40	0.38	1.26	0.47	0.21
1973	4.34	33.23	0.46	2.88	7.46	0.53	0.45	1.30	0.58	0.13
1974	4.79	35.18	0.58	2.85	8.39	0.61	0.48	1.25	0.67	0.07
1975	5.90	31.50	0.80	2.94	9.27	0.62	0.48	1.12	0.80	0.08
1976	6.46	33.23	0.81	2.92	9.73	0.62	0.53	1.22	0.88	0.07
1977	6.97	35.18	0.78	2.95	9.22	0.62	0.62	1.37	0.90	0.08
1978	7.37	36.63	0.68	3.10	10.56	0.69	0.64	1.48	0.85	0.08
1979	7.09	38.35	0.71	3.15	10.25	0.76	0.64	1.54	0.75	0.09
1980	7.16	37.89	0.58	3.29	9.50	0.93	0.61	1.31	0.70	0.08
1981	8.20	37.54	0.53	3.23	7.45	0.87	0.61	1.16	0.69	0.04
1982	8.32	35.61	0.55	3.27	6.75	0.82	0.58	1.15	0.60	0.03
1983	9.73	36.53	0.77	3.38	6.04	0.77	0.55	1.59	0.62	0.03
1984	10.57	39.50	0.88	3.51	6.87	0.68	0.55	1.58	0.55	0.02
1985	11.34	41.28	1.09	3.72	7.42	0.51	0.60	1.62	0.53	0.02
1986	12.15	43.07	1.18	3.95	8.14	0.62	0.67	1.69	0.58	0.03
1987	10.31	43.78	1.04	4.26	8.58	0.59	0.65	1.74	0.54	0.02
1988	11.01	45.54	1.13	4.45	7.87	0.68	0.66	1.74	0.55	0.02

Fraber, K.D. & G.L. Rutledge. 1986. Pollution Abatement and Control Expenditures. Survey of Current Business, table 9, pp. 100-103 (July). U.S. Department of Commerce, Bureau of Economic Analysis. Washington, D.C.

Bratton, D.M. & G.L. Rutledge. 1990. Pollution Abatement and Control Expenditures, 1985-88. Survey of Current Business, table 7, pp. 36-37 (November). U.S. Department of Commerce, Bureau of Economic Analysis. Washington, D.C.

Notes: Expenditures are attributed to the sector that performs the air or water pollution abatement or solid waste collection and disposal. State also includes expenditures by local authorities. Excludes agricultural production except feedlot operations. Totals may not agree with detail on preceding tables because of independent rounding Pers'l=Personal consumption (all of which is to purchase and operate motor vehicle emission abatement devices). Bus.=Business. Fed.=Federal government. Prv't= Private (=business spending). Data do not include interest costs.

Table 12.--Expenditures for pollution abatement, for selected industries, 1973-1988.

(million dollars)

	Chemicals and allied products								
	Capital expenditures				Operating costs				Cost re-covered
Year	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	395.9	164.4	214.6	16.8	502.3	174.1	247.6	80.2	83.1
1974	539.2	250.6	264.4	24.1	643.3	203.8	335.6	104.0	104.5
1975	780.2	359.5	387.7	35.0	807.4	249.9	430.9	126.7	140.7
1976	942.0	319.8	577.4	44.7	983.5	295.6	514.7	173.2	188.7
1977	982.5	339.9	593.1	49.6	1,238.3	335.5	685.2	217.6	206.4
1978	827.5	376.3	385.9	65.1	1,473.0	398.8	794.1	280.1	231.3
1979	770.9	314.6	360.7	95.6	1,667.5	485.3	895.2	287.0	230.4
1980	780.7	325.9	350.0	104.8	1,851.8	539.9	942.9	368.8	305.9
1981	752.8	335.0	322.2	95.6	2,047.8	571.7	1,069.1	406.9	341.1
1982	627.6	272.8	256.5	98.3	2,106.5	556.1	1,112.3	438.2	345.2
1983	395.4	159.0	187.4	49.0	2,198.2	624.9	1,106.0	467.4	297.4
1984	418.1	142.9	212.4	32.7	2,345.4	622.0	1,206.3	517.1	357.5
1985	738.1	193.7	271.5	272.5	2,540.0	672.9	1,267.7	599.4	268.6
1986	624.4	197.8	325.5	101.0	2,654.3	646.5	1,301.8	705.9	336.4
1988	1,095.0	370.0	487.0	236.5	2,893.1	706.4	1,274.1	912.6	443.8

	Petroleum and coal products								
	Capital expenditures				Operating costs				Cost re-covered
Year	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	321.8	222.5	96.1	3.2	337.8	192.5	125.4	19.9	44.3
1974	462.3	341.3	119.7	1.3	420.1	238.3	153.3	28.5	83.5
1975	555.7	398.2	155.7	1.7	563.1	339.4	192.1	31.7	137.7
1976	441.4	236.5	199.8	5.2	774.8	466.1	263.3	45.3	183.8
1977	368.5	167.7	195.6	5.3	948.0	601.3	289.3	57.4	238.4
1978	419.3	311.2	100.5	7.6	997.4	636.4	304.1	57.0	261.8
1979	534.3	397.8	119.4	17.1	1,173.8	750.7	370.8	25.3	324.1
1980	531.9	402.3	114.2	15.4	1,418.0	910.1	406.9	101.0	506.7
1981	590.6	440.8	131.7	18.2	1,685.5	1,118.0	437.2	130.2	565.6
1982	712.1	533.2	165.7	13.1	1,800.8	1,195.1	472.0	133.7	335.3
1983	485.0	308.2	164.7	12.0	1,893.7	1,203.6	552.3	137.9	524.9
1984	311.7	195.1	96.8	19.8	2,083.5	1,327.9	583.8	171.1	552.8
1985	290.4	175.0	88.4	27.0	2,063.4	1,278.5	586.5	198.5	500.0
1986	424.3	273.6	121.5	29.2	2,005.2	1,230.9	578.0	196.4	498.2
1988	482.8	208.2	203.7	70.8	1,975.0	1,175.8	547.1	252.1	480.0

continued

Table 12 (continued).–Expenditures for pollution abatement, for selected industries, 1973-1988.

(millions of dollars)

	Rubber and miscellaneous plastic products								
	Capital expenditures				Operating costs				Cost re- covered
Year	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	24.2	13.5	7.3	3.3	42.6	12.2	10.1	20.4	4.6
1974	37.9	22.2	13.5	2.2	58.8	15.7	15.1	28.2	19.5
1975	31.9	22.2	6.6	3.1	64.8	20.7	18.4	25.7	12.5
1976	37.4	24.2	10.0	3.1	80.3	22.3	24.0	34.0	15.8
1977	36.6	17.4	13.8	5.4	73.8	19.8	18.9	35.1	7.7
1978	27.7	18.7	5.5	3.4	84.9	17.7	23.9	43.3	8.0
1979	25.1	12.9	9.3	2.9	111.7	32.2	29.6	49.9	13.6
1980	21.7	12.6	6.9	2.3	108.2	30.4	27.6	50.2	18.1
1981	21.8	15.3	5.9	6.5	118.3	29.8	29.4	58.8	14.0
1982	25.2	14.8	7.7	2.7	90.2	22.2	28.2	39.8	7.0
1983	23.6	12.0	3.8	7.8	165.8	50.9	52.8	62.0	6.6
1984	33.4	20.5	7.0	5.8	168.0	51.1	48.7	68.1	9.9
1985	29.7	21.3	3.2	5.2	193.1	46.7	55.6	90.8	10.0
1986	36.0	20.1	9.7	6.2	226.2	50.9	52.0	123.3	15.1
1988	40.8	21.7	11.3	7.8	227.2	62.5	35.2	129.3	18.7

	Stone, clay, and glass products								
	Capital expenditures				Operating costs				Cost re- covered
Year	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	150.7	131.6	14.4	4.7	117.0	73.7	16.4	27.0	24.5
1974	208.8	185.8	13.1	10.0	152.9	98.7	24.7	29.4	33.1
1975	173.5	152.7	16.7	4.1	171.8	109.7	28.3	33.8	41.7
1976	104.7	82.2	18.9	3.6	192.1	122.8	30.3	39.0	59.3
1977	133.4	85.8	39.1	8.6	214.5	141.7	28.0	44.5	68.7
1978	123.8	98.1	28.0	3.7	251.1	163.7	33.2	54.2	74.8
1979	145.6	110.2	25.4	10.0	293.6	188.0	45.1	60.5	82.4
1980	151.0	123.1	17.9	10.0	301.7	182.1	48.2	71.4	83.9
1981	188.5	165.5	13.8	9.2	310.7	191.0	47.3	72.5	91.5
1982	105.2	84.9	14.0	6.3	260.2	142.8	44.0	39.8	56.0
1983	95.9	57.9	9.8	28.2	320.4	179.9	55.8	84.6	45.2
1984	84.0	65.6	13.1	5.2	377.9	215.0	64.2	98.7	46.2
1985	61.9	44.4	9.9	7.5	393.2	217.2	66.7	109.3	31.5
1986	84.4	53.1	13.7	17.6	423.6	237.0	68.2	118.3	46.7
1988	62.3	42.6	13.6	6.1	410.7	247.7	50.6	112.6	103.3

continued

Table 12 (continued).–Expenditures for pollution abatement, for selected industries, 1973-1988.

(millions of dollars)

Year	Primary metal industries								Cost re-covered
	Capital expenditures				Operating costs				
	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	498.6	397.2	84.7	16.8	466.8	264.7	148.3	53.8	51.5
1974	646.8	510.5	132.7	12.5	590.2	339.6	181.2	69.5	76.9
1975	833.5	640.6	187.5	5.4	715.2	429.9	209.4	75.9	95.3
1976	833.7	632.5	197.8	3.4	895.8	575.7	229.5	90.7	100.7
1977	874.6	616.0	250.2	8.4	1,122.3	721.6	268.3	132.3	128.3
1978	791.8	563.3	219.1	9.4	1,321.4	809.6	333.0	178.9	141.7
1979	823.1	588.8	227.3	6.9	1,587.2	981.7	442.0	163.5	241.8
1980	740.0	539.7	180.7	19.6	1,677.3	998.2	463.2	215.3	169.5
1981	728.2	567.2	144.1	16.9	1,911.8	1,111.9	549.2	250.7	189.7
1982	569.8	423.1	133.7	13.0	1,513.6	897.2	448.4	167.6	148.5
1983	225.3	147.6	100.2	7.5	1,615.6	904.3	454.6	256.7	95.4
1984	274.0	175.2	72.9	26.0	1,769.7	1,017.3	450.7	301.7	171.6
1985	252.9	142.9	84.3	25.6	1,863.0	1,067.0	517.4	278.7	136.8
1986	225.9	102.8	74.6	48.4	1,721.9	968.5	509.4	264.1	184.6
1988	309.8	167.3	100.6	41.8	1,746.6	965.8	468.5	311.2	189.6

Year	Fabricated metal products								Cost re-covered
	Capital expenditures				Operating costs				
	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	63.7	39.6	21.5	2.7	84.8	27.0	35.7	22.2	9.1
1974	90.5	56.4	28.2	5.9	110.1	34.5	44.9	30.7	8.2
1975	77.5	46.9	29.0	1.7	109.5	32.6	45.7	31.3	7.5
1976	72.9	35.5	34.1	3.4	124.3	35.4	52.7	36.1	6.3
1977	76.7	32.5	39.2	5.0	149.2	40.3	66.1	42.8	3.5
1978	61.6	33.1	26.2	2.3	168.7	42.1	73.8	52.8	4.5
1979	66.1	36.7	24.5	4.9	220.9	57.0	99.7	64.2	13.4
1980	76.4	37.5	34.8	4.2	219.2	49.0	88.2	81.9	23.9
1981	75.7	37.5	30.4	7.6	230.5	51.6	93.4	85.0	21.5
1982	95.9	57.9	43.3	6.7	223.5	48.6	103.4	71.5	13.0
1983	70.6	27.0	32.9	10.6	366.3	81.9	137.8	146.6	17.7
1984	125.3	25.2	82.5	17.6	348.5	64.9	128.2	155.4	37.0
1985	116.9	40.4	59.7	16.8	408.1	79.4	163.2	165.5	15.4
1986	135.8	36.7	80.9	18.2	502.5	95.6	187.7	219.2	27.1
1988	146.8	45.4	75.3	26.1	688.9	135.0	267.8	286.0	29.1

continued

Table 12 (continued).--Expenditures for pollution abatement, for selected industries, 1973-1988.

(millions of dollars)

Year	Machinery, except electrical								Cost re-covered
	Capital expenditures				Operating costs				
	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	56.3	36.6	15.6	4.1	72.5	19.7	23.0	29.9	14.3
1974	67.7	41.9	17.6	8.1	91.7	24.3	29.1	38.2	11.0
1975	60.5	37.5	20.8	2.3	98.0	28.4	33.7	36.0	11.9
1976	69.4	44.8	21.8	2.9	117.9	30.8	37.7	49.6	15.9
1977	90.2	42.3	42.4	5.5	135.4	33.1	49.8	52.6	17.6
1978	81.5	41.2	27.8	12.6	158.8	41.0	54.4	63.1	14.8
1979	84.5	38.5	38.2	7.8	200.2	50.1	69.0	81.1	19.9
1980	74.5	34.0	34.9	5.6	206.4	48.0	73.0	85.3	17.6
1981	67.1	30.9	28.0	8.2	220.9	47.3	81.6	91.7	18.1
1982	78.2	29.2	42.2	6.8	207.6	46.6	85.3	75.7	11.4
1983	51.0	17.7	19.0	14.3	290.5	58.0	105.0	127.5	18.8
1984	43.1	13.8	22.6	6.7	314.4	68.4	115.7	130.3	15.8
1985	69.0	21.2	35.1	12.7	344.0	76.0	119.9	147.7	12.1
1986	48.7	16.7	25.7	6.3	358.8	81.4	128.3	149.1	12.6
1988	77.2	21.8	33.2	22.3	373.1	68.4	101.2	203.4	14.7

Year	Electric, electronic equipment								Cost re-covered
	Capital expenditures				Operating costs				
	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	52.7	27.0	22.2	3.5	87.2	20.2	38.9	28.1	18.5
1974	55.6	24.6	28.0	3.1	88.6	22.7	39.8	26.2	20.3
1975	52.3	22.7	26.2	3.3	97.3	27.6	43.1	26.7	14.3
1976	58.4	23.0	31.3	4.1	109.9	26.8	50.8	32.3	23.7
1977	63.8	23.0	36.0	4.9	128.1	28.0	63.2	37.1	16.0
1978	72.2	32.9	36.0	3.3	148.6	30.7	71.7	46.1	12.9
1979	90.9	41.8	42.0	7.1	182.3	46.7	82.8	52.8	24.1
1980	79.0	43.5	27.1	8.4	205.0	45.2	87.8	71.9	17.0
1981	97.1	48.7	41.0	7.4	247.1	51.8	106.2	88.8	22.0
1982	105.9	58.1	40.9	6.9	260.2	55.1	116.6	88.7	14.2
1983	97.0	43.8	45.1	8.0	353.8	77.3	142.0	134.5	15.1
1984	112.4	38.3	59.5	14.6	364.0	74.6	150.3	139.1	18.3
1985	137.7	45.4	74.1	18.3	428.2	78.0	174.0	176.3	15.2
1986	125.1	46.6	61.5	17.0	530.8	88.3	210.9	231.5	19.4
1988	154.2	80.6	54.6	19.0	573.2	92.2	189.9	291.1	39.1

continued

Table 12 (continued).--Expenditures for pollution abatement, for selected industries, 1973-1988.

(millions of dollars)

Year	Transportation equipment								Cost re-covered
	Capital expenditures				Operating costs				
	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	101.2	52.6	41.7	6.9	129.8	35.2	51.1	43.4	20.1
1974	103.4	52.7	41.5	9.2	154.8	44.8	59.5	50.5	13.6
1975	75.4	32.1	36.4	6.8	168.3	52.2	66.4	49.7	13.4
1976	78.5	21.1	53.6	3.8	197.9	56.9	83.5	57.6	14.5
1977	82.6	36.9	39.4	6.3	233.9	60.6	97.3	76.1	13.5
1978	139.5	71.0	57.9	10.7	280.5	77.3	110.2	93.0	16.6
1979	189.5	120.1	59.5	99.9	331.8	96.4	126.3	109.1	36.9
1980	275.0	201.4	60.7	12.9	401.5	110.7	137.4	153.2	24.6
1981	283.3	209.2	60.0	14.2	426.1	117.5	150.7	157.7	19.3
1982	108.3	59.7	36.5	12.1	396.5	105.6	153.5	137.6	18.2
1983	98.3	33.0	55.0	10.2	560.3	157.5	224.2	178.6	22.3
1984	207.6	71.3	116.9	19.4	685.6	192.9	280.1	212.6	22.7
1985	456.5	254.5	165.1	36.9	738.8	194.5	283.9	260.3	23.7
1986	541.1	432.4	81.8	26.8	839.0	195.7	338.5	304.9	28.2
1988	210.2	87.6	80.4	42.2	891.9	215.7	239.0	437.1	38.7

Year	Instruments and related products								Cost re-covered
	Capital expenditures				Operating costs				
	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	11.8	3.0	5.6	3.2	21.9	2.0	11.3	8.6	2.2
1974	15.7	3.6	6.7	5.5	34.1	4.9	15.0	14.3	3.5
1975	29.6	11.2	17.3	1.1	38.5	5.9	19.5	13.2	4.3
1976	32.3	10.9	12.2	9.3	45.7	8.7	22.3	14.8	11.6
1977	24.4	14.5	8.5	1.4	47.3	9.0	23.0	15.4	6.1
1978	16.9	6.8	9.5	0.6	55.8	7.3	26.9	21.6	5.0
1979	23.2	13.0	7.7	2.5	69.2	10.6	30.7	27.9	15.2
1980	27.2	11.3	12.7	3.2	77.1	11.3	33.7	32.1	11.8
1981	40.1	14.4	23.7	2.1	90.4	12.8	40.0	37.9	9.4
1982	30.0	18.7	9.8	1.4	80.2	12.9	33.9	33.3	10.3
1983	21.1	10.4	9.5	1.2	163.8	25.0	53.9	85.0	11.2
1984	23.7	10.9	11.1	1.7	161.9	23.6	67.3	70.8	w/h
1985	24.8	13.8	7.8	3.1	165.1	24.2	71.8	69.1	10.9
1986	18.8	10.8	5.1	2.9	164.4	19.9	78.6	66.0	12.0
1988	30.7	15.5	11.8	3.4	175.6	21.7	61.7	91.3	19.5

continued

Table 12 (continued).--Expenditures for pollution abatement, for selected industries, 1973-1988.

(millions of dollars)

	Food and kindred products								
	Capital expenditures				Operating costs				Cost re-covered
Year	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	196.7	77.6	104.8	14.3	203.1	39.1	110.4	53.6	32.6
1974	199.2	73.4	111.7	14.3	268.9	48.8	143.5	76.8	52.2
1975	180.9	75.6	93.9	11.4	294.2	53.2	153.7	87.7	62.6
1976	207.5	102.5	97.6	7.4	345.9	57.7	187.5	100.5	63.7
1977	183.9	67.9	103.6	12.5	357.1	56.2	211.6	89.5	53.3
1978	175.0	67.7	94.4	12.9	412.0	69.4	243.2	99.4	57.1
1979	182.7	57.9	111.1	13.6	504.2	91.0	297.9	115.3	80.3
1980	208.2	61.7	133.0	13.5	519.4	81.6	314.3	123.6	79.5
1981	173.5	53.9	104.8	14.8	579.1	78.3	343.3	157.5	91.2
1982	169.3	47.4	110.9	11.0	522.1	77.1	328.1	116.2	51.1
1983	153.8	37.7	105.1	10.9	649.6	96.1	402.3	151.3	32.7
1984	154.5	50.6	91.8	12.2	714.4	101.3	458.1	155.0	43.7
1985	155.1	66.2	77.4	11.7	832.1	106.3	525.2	201.0	33.4
1986	185.8	61.9	108.2	15.7	932.1	126.0	559.9	246.1	w/h
1988	211.0	100.2	91.0	19.8	761.5	157.8	325.6	278.1	110.6

	Textile mill products								
	Capital expenditures				Operating costs				Cost re-covered
Year	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	29.2	10.3	17.7	1.2	38.8	6.3	23.5	9.0	2.8
1974	32.0	12.7	17.7	1.7	54.0	9.4	31.3	13.3	2.5
1975	43.0	19.7	22.2	1.1	50.7	9.4	29.4	12.0	w/h
1976	53.3	9.2	42.6	1.6	65.3	9.2	41.8	14.3	8.4
1977	36.7	20.7	14.7	1.4	75.0	10.9	46.4	31.0	6.6
1978	59.7	42.7	15.4	1.6	92.5	19.0	51.6	21.9	w/h
1979	39.2	21.9	15.2	2.1	101.7	19.0	60.2	22.5	10.5
1980	59.5	32.5	23.6	3.5	115.8	16.6	59.3	39.9	13.4
1981	48.0	27.2	16.2	4.6	108.5	18.9	60.2	29.4	18.2
1982	22.0	12.2	6.2	3.6	74.7	14.8	41.4	18.3	7.6
1983	18.7	9.4	8.4	0.9	101.1	21.3	54.5	25.4	5.4
1984	20.9	12.8	6.3	1.8	122.2	25.8	68.4	28.0	5.3
1985	24.7	12.2	10.3	2.1	148.9	30.9	82.6	35.4	3.3
1986	25.5	12.3	10.5	2.6	161.6	28.5	94.9	38.2	w/h
1988	18.9	8.0	8.0	2.9	114.6	30.5	48.8	35.3	10.7

continued

Table 12 (continued).--Expenditures for pollution abatement, for selected industries, 1973-1988.

(millions of dollars)

Year	Lumber and wood products								Cost recovered
	Capital expenditures				Operating costs				
	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	62.7	41.5	11.7	9.6	61.6	14.9	18.5	28.2	7.6
1974	81.1	58.4	7.6	15.0	64.2	19.5	14.0	30.8	12.8
1975	75.1	46.4	7.7	21.0	70.5	22.7	19.6	28.3	17.4
1976	51.1	29.5	9.2	12.5	81.3	26.6	21.1	33.6	25.5
1977	59.9	33.9	19.1	6.9	73.4	20.4	19.2	33.9	15.3
1978	84.5	46.9	25.6	12.0	90.7	27.7	19.4	43.7	26.7
1979	93.6	67.5	12.3	13.8	115.4	40.2	25.5	49.7	28.4
1980	81.5	55.8	15.6	10.1	129.1	39.6	32.9	56.4	37.6
1981	78.5	49.2	10.5	18.8	134.7	43.2	26.9	64.6	29.7
1982	33.2	20.0	11.7	1.5	87.1	26.4	23.4	37.3	16.6
1983	25.2	18.0	4.0	3.2	102.8	31.1	27.8	43.9	9.0
1984	48.5	24.1	18.8	5.7	114.2	41.2	30.7	42.4	13.6
1985	34.5	15.2	6.3	13.0	139.1	41.8	35.3	62.0	10.4
1986	33.3	17.8	11.0	4.6	178.9	61.7	42.6	74.7	14.7
1988	44.5	31.6	7.5	5.4	215.9	84.0	47.5	84.4	24.0

Year	Paper and allied products								Cost recovered
	Capital expenditures				Operating costs				
	Total	Air	Water	Solid waste	Total	Air	Water	Solid waste	
1973	339.6	166.4	161.0	12.1	220.5	59.2	118.1	43.2	54.6
1974	476.9	270.8	193.2	12.9	289.0	81.2	152.0	55.7	84.8
1975	605.3	323.0	266.0	16.3	344.0	100.9	185.5	57.5	112.2
1976	486.6	180.6	278.6	27.3	430.3	123.3	239.1	67.3	137.6
1977	427.4	134.1	261.7	31.6	529.0	133.5	309.0	86.4	150.8
1978	341.6	123.9	189.0	28.7	622.0	158.4	357.6	105.6	175.6
1979	426.4	207.0	180.6	38.8	698.2	176.6	400.5	121.1	161.5
1980	339.6	197.4	111.2	31.0	762.1	196.2	436.7	129.1	248.1
1981	285.5	168.0	86.5	31.1	829.7	211.8	469.9	148.0	298.5
1982	313.4	190.0	93.7	29.7	796.0	206.7	455.2	134.1	213.7
1983	216.1	122.3	65.9	27.9	919.1	226.5	508.9	183.6	255.3
1984	262.3	151.9	68.2	42.1	1,060.1	280.7	566.1	213.2	118.4
1985	332.4	190.9	106.0	35.6	1,120.8	313.0	573.4	234.4	107.3
1986	271.3	137.1	96.9	37.3	1,154.6	319.2	565.7	269.7	133.8
1988	417.7	233.4	97.2	87.1	1,201.7	374.4	520.0	309.4	245.6

Source: U.S. Department of Commerce, Bureau of the Census. Pollution abatement costs and expenditures, annual. Current industrial reports, MA-200. Washington, D.C.

Notes: The survey was not conducted in 1987. w/h=withheld to avoid disclosing operations of individual companies.

Table 13.--Expenditures on the environment, by state and local governments, 1970-1988.

(thousand dollars)

Year	Natural resources	Parks & recreation	Sewerage	Solid waste management
1970	2,732	1,888	2,167	1,246
1971	3,082	2,109	2,646	1,441
1972	3,122	2,318	3,259	1,586
1973	3,278	2,561	3,604	1,718
1974	3,661	2,951	4,080	1,915
1975	4,223	3,462	5,262	2,176
1976	4,662	3,864	5,937	2,302
1977	4,049	4,919	7,052	2,374
1978	4,225	5,270	7,142	2,727
1979	4,706	5,896	8,795	2,992
1980	5,509	6,520	9,892	3,322
1981	6,175	7,064	11,121	3,777
1982	6,567	7,501	10,806	4,134
1983	7,082	8,050	11,239	4,364
1984	7,421	8,344	11,516	4,710
1985	8,357	9,160	12,186	5,212
1986	9,074	10,164	13,307	5,835
1987	9,943	11,018	15,148	6,499
1988	10,238	12,069	16,328	7,350

Source: U.S. Department of Commerce, Bureau of the Census. 1982. Historical Statistics on Governmental Finances and Employment. GC82(6)-4. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. Governmental Finances, series GF No. 5, annual.

Note: Historical trend data are available from 1902, as reported in Sources above.

Table 14.–Risks and cost-effectiveness of selected regulations, by cost per premature death averted.

Regulation*	Year issued	Health or safety	Agency	Baseline mortality risk per million exposed	Cost per premature death averted (million 1990 $)
Unvented Space Heater Ban	1980	S	CPSC	1,890	0.1
Aircraft Cabin Fire Protection Std.	1965	S	FAA	5	0.1
Auto Passive Restraint/Seat Belt Std.	1984	S	NHTSA	6,370	0.1
Steering Column Protection Std.**	1967	S	NHTSA	385	0.1
Underground Construction Stds.***	1989	S	OSHA-S	38,700	0.1
Trihalomethane Drinking Water Stds.	1979	H	EPA	420	0.2
Aircraft Seat Cushion Flammability Std.	1984	S	FAA	11	0.4
Alcohal and Drug Control Stds.***	1985	H	FRA	81	0.4
Auto Fuel-System Integrity Std.	1975	S	NHTSA	343	0.4
Stds. for Servicing Auto Wheel Rims***	1984	S	OSHA-S	630	0.4
Aircraft Floor Emerency Lighting Std.	1984	S	FAA	2	0.6
Concrete & Masonry Construct. Std.***	1988	S	OSHA-S	630	0.6
Crane Suspended Pers. Platf'm Std.***	1988	S	OSHA-S	81,000	0.7
Passive Restrainsts - Truck & Bus (P)	1989	S	NHTSA	6,370	0.7
Side-Impact Stds. for Autos (Dynamic)	1990	S	NHTSA	na	0.8
Children's Sleepwear Flam'lity Ban****	1973	S	CPSC	29	0.8
Auto Side Door Support Stds.	1970	S	NHTSA	2,520	0.8
Low-Alt. Windsh'r Equip. & Train. Std.	1988	S	FAA	na	1.3
Electrical Equip't Stds. (Metal Mines)	1970	S	MSHA	na	1.4
Trenching $ Excavation Stds.***	1989	S	OSHA-S	14,310	1.5
Traffic Alert & Collision Avoidance Sys.	1988	S	FAA	na	1.5
Hazard Communication Std.***	1983	S	OSHA-S	1,800	1.6
Side-Impact - Truck, Buss & MPV (P)	1989	S	NHTSA	na	2.2
Grain Dust Explosion Prev'n Stds***	1987	S	OSHA-S	9,450	2.8
Rear Lap/Shoulder Belts for Autos	1989	S	NHTSA	na	3.2
Radionuclides - Uran. Mines Stds.***	1984	H	EPA	6,300	3.4
Benzene NESHAP (Fugitive Emis'n)	1984	H	EPA	1,470	3.4
Ethylene Dibromide Drinking Water Std.	1991	H	EPA	na	5.7
Benzene NESHAP (Coke By-Prod.)***	1988	H	EPA	na	6.1
Asbestos Occup'l Exposure Limit***	1972	H	OSHA-H	3,015	8.3
Benzene Occup'l Exposure Limit***	1987	H	OSHA-H	39,600	8.9
Electrical Equip. Stds. (Coal Mines)***	1970	S	MSHA	na	9.2
Arsenic Emis'n Stds. - Glass Plants	1986	H	EPA	2,660	13.5
Ethylene Oxide Occup'l Expos. Limit***	1984	H	OSHA-H	1,980	20.5
Arsenic/Copper NESHAP	1986	H	EPA	63,000	23.0
Haz Waste List - Petrol. Refin. Sludge	1990	H	EPA	210	27.6

continued

Table 14 (continued).--Risks and cost-effectiveness of selected regulations, by cost per premature death averted.

Regulation*	Year issued	Health or safety	Agency	Baseline mortality risk per million exposed	Cost per premature death averted (million 1990 $)
Cover/Move Uran. Tail'gs (Inact. Sites)	1983	H	EPA	30,100	31.7
Benezene NESHAP (Trans. Oper'ns)	1990	H	EPA	na	32.9
Cover/Move Uran. Tailings (Act. Sites)	1983	H	EPA	30,100	45.0
Acrylonitrile Occup'l Expos. Limit***	1978	H	OSHA-H	42,300	51.5
Coke Ovens Occup'l Expos. Limit***	1976	H	OSHA-H	7,200	63.5
Lockout/Tagout***	1989	S	OSHA-S	4	70.9
Asbestos Occup'l Expos. Limit***	1986	H	OSHA-H	3,015	74.0
Arsenic Occup'l Expos. Limit***	1978	H	OSHA-H	14800	106.9
Asbestos Ban	1989	H	EPA	na	110.7
Diethylstilbestrol (DES) Cattlefeed Ban	1979	H	FDA	22	124.8
Benezene NESHAP (Waste Oper'ns)	1990	H	EPA	na	168.2
1,2-Dichloropropane Drink. Water Std.	1991	H	EPA	na	653.0
Haz Waste Land Disposal Ban (1st 3rd)	1988	H	EPA	2	4,190.4
Municipal Solid Waste Landfill Std. (P)	1988	H	EPA	<1	19,107.0
Formaldehyde Occup'l Expos. Limit***	1987	H	OSHA-H	31	86,201.8
Atrazine/Alachlor Drinking Water Std.	1991	H	EPA	na	92,069.7
Haz Waste List - Wood Preser. Chems.	1990	H	EPA	<1	5,700,000.0

Source: J.F. Morrall, III. 1986. A Review of the Record. Regulation, vol. 10, no. 2, p. 30. Updated by the Author, et al. AS IN: Executive Office of the President, The Budget for Fiscal Year 1992.

Notes: *=70-year lifetime exposure assumed unless otherwise specified. **=50-year lifetime exposure. ***=45-year lifetime exposure. ****=12-year lifetime exposure. na=not available. Agency abreviations--CPSC: Consumer Product Safety Commission; MSHA: Mine Safety and Health Administration; EPA: Environmental Protection Agency; NHTSA: National Highway Traffic Safety Administration; FAA: Federal Aviation Administration; FRA: Federal Railroad Administration; FDA: Food and Drug Administration; OSHA-H: Occupational Safety and Health Administration, Health Standards; OSHA-S: Occupational Safety and Health Administration, Safety Standards.

Table 15.--Environmental Impact Statements filed, by federal agency, 1979-1990.

Agency	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Agriculture	172	104	102	89	59	65	117	118	75	68	89	136
Commerce	54	53	36	25	14	24	10	8	9	3	5	8
Defense	1	1	1	1	1	0	0	0	2	0	0	0
Air Force	8	3	7	4	6	5	7	8	9	6	11	19
Army	40	9	14	3	6	5	5	2	10	8	9	9
COE	182	150	186	127	119	116	106	91	76	69	40	46
Navy	11	9	10	6	4	9	8	13	9	6	4	19
Energy	28	45	21	24	19	14	4	13	11	9	6	11
EPA	84	71	96	63	67	42	16	18	19	23	25	31
GSA	13	11	13	8	1	0	4	0	1	3	0	4
HUD	170	140	140	93	42	13	15	18	6	2	7	5
Interior	126	131	107	127	146	115	105	98	110	117	61	68
Transportation	277	189	221	183	169	147	126	110	101	96	90	100
TVA	9	6	4	0	2	1	0	1	0	0	0	3
Other	98	44	76	55	22	21	26	15	17	20	23	18
Total	1,273	966	1,033	808	677	577	549	521	455	430	370	477

Source: U.S. Environmental Protection Agency, Office of Federal Activities, unpublished data. Washington, D.C.

Notes: Years refer to calendar years. Number of Environmental Impact Statements (EISs) includes draft EISs, EIS supplements, and final EISs filed during the specified year. Some proposed projects may have several draft and final EISs filed over a period of years. HUD= Department of Housing and Urban Development. EPA=U.S. Environmental Protection Agency. GSA=General Services Administration. TVA=Tennessee Valley Authority.

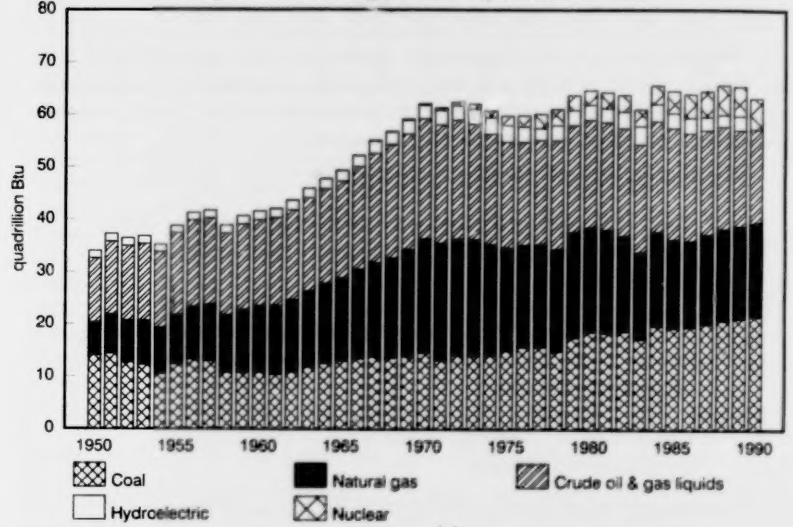
Energy

Energy use is a key component of the national standard of living but the extraction of fuels and the production of energy can have significant environmental impacts. Data are presented on the nation's energy production, imports, exports, and consumption.

Highlights include the following trends:

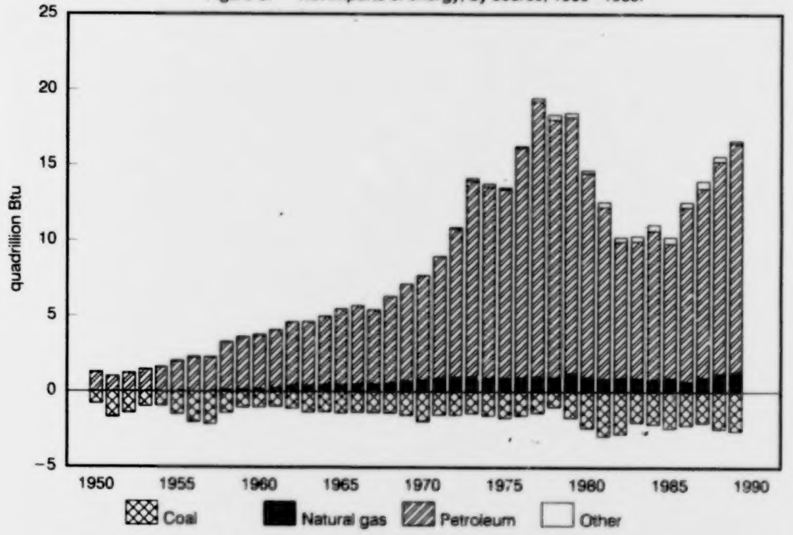
- Total U.S. energy production has remained stable for the past two decades; oil, coal, and natural gas are the dominant fuels.
- Currently the United States produces 82 percent of the energy it consumes; most of the imported energy is crude oil and natural gas.
- Consumption of energy in the form of electricity continues to increase.
- Energy consumption per capita has resumed an upward path after decreasing in the early 1980s.
- Energy consumption per dollar of GNP has leveled off after decreasing in the decade after 1973.
- More miles are being traveled per capita in personal vehicles but, with increased fuel efficiency, fuel consumption per capita remains constant.

Figure 7.--U.S. energy production, by source, 1950-1990.



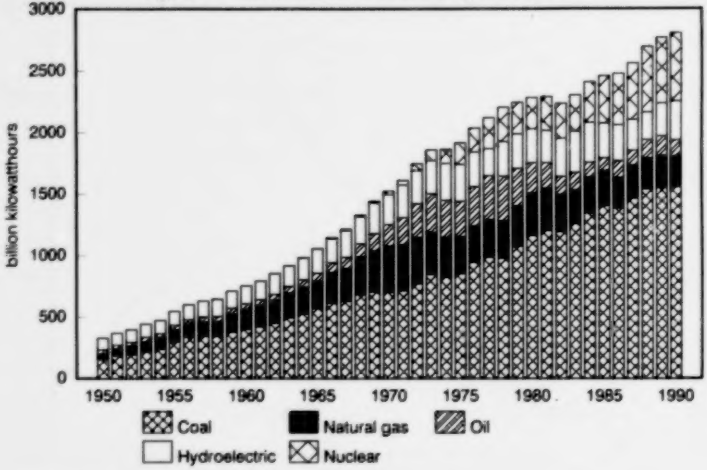
Source: See Table 16.

Figure 8.--Net imports of energy, by source, 1950-1989.



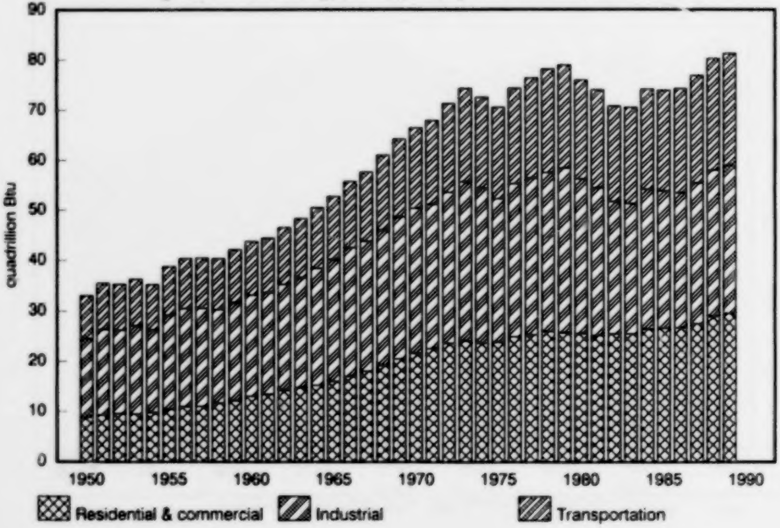
Source: See Table 22.

Figure 9.--U.S. production of electricity, by source, 1950-1990.



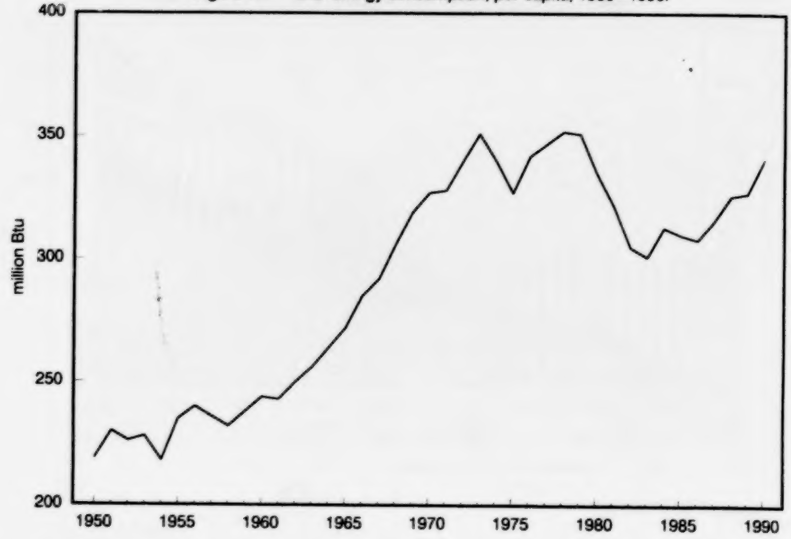
Source: See Table 20.

Figure 10.--U.S. energy consumption, by end use sector, 1950-1989.



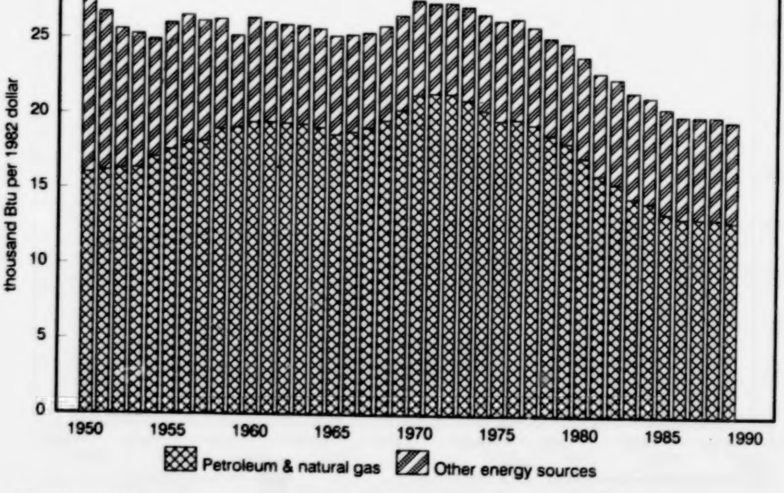
Source: See Table 23.

Figure 11.--U.S. energy consumption, per capita, 1950-1990.



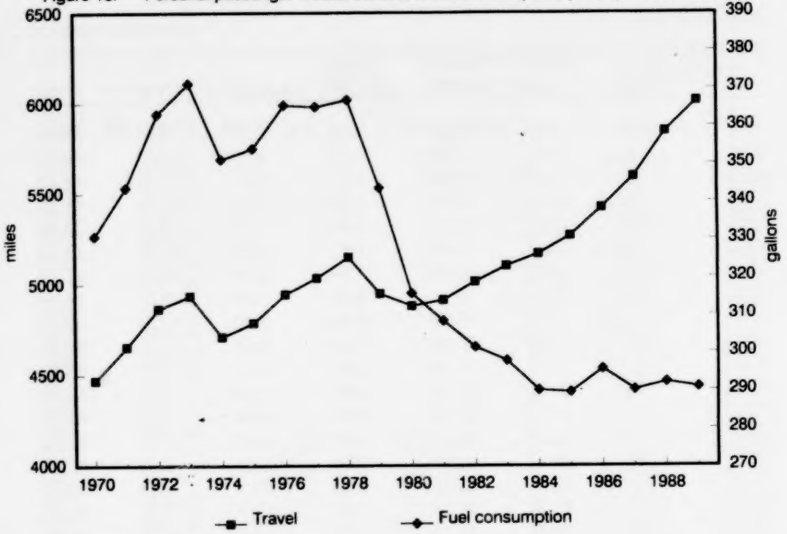
Source: See Table 24.

Figure 12.--U.S. energy consumption, per dollar of GNP, 1950-1989.



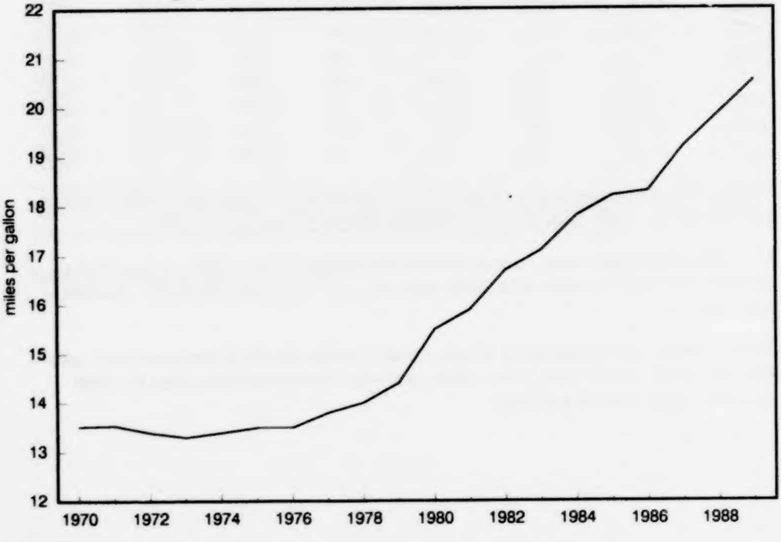
Source: See Table 25.

Figure 13.--Personal passenger vehicle travel and fuel consumption, per capita, 1970-1989.



Source: See Table 27.

Figure 14.--Personal passenger vehicle fuel efficiency, 1970-1989.



Source: See Table 27.

Table 16.–U.S. energy production, by source, 1950-1990.

(quadrillion Btu)

Year	Coal	Natural gas	Crude oil & NGPL	Hydro-electric	Nuclear	Other	Total
1950	14.06	6.23	12.27	1.42	0.00	0.01	33.98
1955	12.37	9.34	15.65	1.36	0.00	<0.01	38.73
1960	10.82	12.66	16.39	1.61	0.01	<0.01	41.49
1961	10.45	13.10	16.76	1.66	0.02	<0.01	41.99
1962	10.90	13.72	17.11	1.82	0.03	<0.01	43.58
1963	11.85	14.51	17.68	1.77	0.04	<0.01	45.85
1964	12.52	15.30	17.96	1.89	0.04	<0.01	47.72
1965	13.06	15.78	18.40	2.06	0.04	<0.01	49.34
1966	13.47	17.01	19.56	2.06	0.06	<0.01	52.17
1967	13.83	17.94	20.83	2.35	0.09	0.01	55.04
1968	13.61	19.07	21.63	2.35	0.14	0.01	56.81
1969	13.86	20.45	21.98	2.65	0.15	0.01	59.10
1970	14.61	21.67	22.91	2.63	0.24	0.01	62.07
1971	13.19	22.28	22.57	2.82	0.41	0.01	61.29
1972	14.09	22.21	22.64	2.86	0.58	0.03	62.42
1973	13.99	22.19	22.06	2.86	0.91	0.04	62.06
1974	14.07	21.21	21.04	3.18	1.27	0.05	60.84
1975	14.99	19.64	20.10	3.15	1.90	0.07	59.86
1976	15.65	19.48	19.59	2.98	2.11	0.08	59.89
1977	15.76	19.57	19.78	2.33	2.70	0.09	60.22
1978	14.91	19.49	20.68	2.94	3.02	0.06	61.10
1979	17.54	20.08	20.39	2.93	2.78	0.09	63.80
1980	18.60	19.91	20.50	2.90	2.74	0.11	64.76
1981	18.38	19.70	20.46	2.76	3.01	0.12	64.42
1982	18.64	18.25	20.50	3.27	3.13	0.10	63.89
1983	17.25	16.53	20.57	3.53	3.20	0.13	61.19
1984	19.72	17.93	21.12	3.35	3.55	0.17	65.81
1985	19.33	16.91	21.23	2.94	4.15	0.21	64.76
1986	19.51	16.47	20.53	3.02	4.47	0.23	64.23
1987	20.14	17.05	19.89	2.59	4.91	0.25	64.82
1988	20.74	17.49	19.54	2.31	5.66	0.24	65.97
1989	21.23	17.53	18.31	2.74	5.69	0.24	65.71
1990	21.60	18.80	17.90	na	5.90	na	69.90

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 2, p. 9. DOE/EIA-0384(89). Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Outlook 1990 with Projections to 2010, table A2, p. 41. DOE/EIA-0383(90). Washington, D.C.

Notes: NGPL= Natural gas plant liquids. Other includes electricity produced from geothermal, wood, waste, wind, photovoltaic, and solar thermal sources. Data for 1990 are projections. na=not available.

Table 17.--U.S. coal production, by rank and mining method, 1950-1989.

(million metric tons)

	Rank				Mining method	
Year	Bituminous	Sub-bituminous	Lignite	Anthracite	Under-ground	Surface
1950	468.29	i	i	39.98	381.85	126.42
1955	421.42	i	i	23.77	324.67	120.52
1960	376.87	i	i	17.07	265.37	128.56
1961	365.50	i	i	15.82	253.55	127.77
1962	382.89	i	i	15.32	261.16	137.05
1963	416.25	i	i	16.57	280.24	152.58
1964	441.71	i	i	15.59	297.22	160.07
1965	464.46	i	i	13.48	306.53	171.42
1966	484.23	i	i	11.74	310.75	185.22
1967	501.23	i	i	11.12	319.62	192.73
1968	494.54	i	i	10.40	314.36	190.57
1969	496.29	7.55	4.55	9.50	316.76	201.12
1970	524.67	14.90	7.29	8.82	308.86	246.82
1971	472.86	20.09	7.89	7.92	251.40	257.36
1972	505.06	24.99	9.97	6.45	276.68	269.78
1973	492.98	30.78	12.95	6.19	272.17	270.73
1974	494.94	38.31	14.04	6.00	252.12	301.18
1975	523.81	46.35	17.97	5.63	266.17	327.58
1976	533.65	58.81	23.11	5.65	267.99	353.23
1977	526.96	74.48	25.61	5.32	241.80	390.57
1978	484.36	87.76	31.16	4.57	220.19	387.64
1979	555.34	110.18	38.59	4.39	291.05	417.44
1980	570.29	133.98	42.77	5.49	306.12	446.42
1981	551.44	144.84	45.96	4.92	287.06	460.10
1982	562.49	145.98	47.54	4.16	307.61	452.56
1983	515.73	137.00	52.92	3.71	272.44	436.91
1984	589.09	162.53	57.20	3.77	319.31	493.29
1985	556.92	174.82	65.68	4.26	318.24	483.35
1986	562.55	172.00	69.31	3.90	326.95	480.72
1987	577.42	181.59	71.11	3.27	338.23	495.15
1988	578.78	205.90	79.46	3.18	359.37	524.72
1989	595.55	206.17	79.49	3.18	359.53	637.51

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 80, p. 183. DOE/EIA-0384(89). Washington, D.C.

Note: i=included in bituminous coal.

Table 18.--U.S. petroleum production, 1940-1989.

(million barrels per day)

Year	Crude oil	Natural gas plant liquids	Year	Crude oil	Natural gas plant liquids
1940	3.707	0.153	1965	7.804	1.210
1941	3.842	0.222	1966	8.295	1.284
1942	3.799	0.227	1967	8.810	1.409
1943	4.125	0.241	1968	9.121	1.508
1944	4.597	0.274	1969	9.238	1.590
1945	4.695	0.307	1970	9.637	1.660
1946	4.751	0.318	1971	9.463	1.693
1947	5.088	0.362	1972	9.467	1.749
1948	5.535	0.403	1973	9.208	1.738
1949	5.046	0.430	1974	8.774	1.688
1950	5.407	0.499	1975	8.375	1.633
1951	6.158	0.561	1976	8.154	1.608
1952	6.274	0.612	1977	8.245	1.618
1953	6.458	0.654	1978	8.707	1.567
1954	6.342	0.691	1979	8.552	1.584
1955	6.807	0.771	1980	8.600	1.577
1956	7.171	0.802	1981	8.572	1.609
1957	7.170	0.808	1982	8.649	1.550
1958	6.710	0.808	1983	8.688	1.559
1959	7.054	0.879	1984	8.880	1.634
1960	7.055	0.932	1985	8.970	1.610
1961	7.183	0.991	1986	8.680	1.550
1962	7.332	1.021	1987	8.350	1.600
1963	7.542	1.098	1988	8.130	1.620
1964	7.635	1.157	1989	7.630	1.620

Source: Bureau of the Census. 1976. Historical Statistics of the United States: Colonial Times to 1970, series M 143, 138. Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 50, p. 115. DOE/EIA-0384(89). Washington, D.C.

Notes: Crude oil includes lease condensate.

Table 19.--U.S. natural gas production, 1900-1989.

(trillion cubic feet)

Year	Well production	Year	Well production	Year	Well production
1900	0.128	1930	1.979	1960	12.771
1901	0.180	1931	1.722	1961	13.250
1902	0.206	1932	1.594	1962	13.880
1903	0.239	1933	1.597	1963	14.750
1904	0.257	1934	1.816	1964	15.550
1905	0.320	1935	1.969	1965	16.040
1906	0.389	1936	2.225	1966	17.207
1907	0.407	1937	2.473	1967	18.171
1908	0.402	1938	2.358	1968	19.322
1909	0.481	1939	2.538	1969	20.698
1910	0.509	1940	2.734	1970	21.921
1911	0.513	1941	2.894	1971	22.490
1912	0.562	1942	3.146	1972	22.530
1913	0.582	1943	3.516	1973	22.650
1914	0.592	1944	3.815	1974	21.600
1915	0.629	1945	4.042	1975	20.110
1916	0.753	1946	4.153	1976	19.950
1917	0.795	1947	4.582	1977	20.030
1918	0.721	1948	5.148	1978	19.970
1919	0.746	1949	5.420	1979	20.470
1920	0.812	1950	6.282	1980	20.180
1921	0.674	1951	7.457	1981	19.960
1922	0.776	1952	8.013	1982	18.520
1923	1.025	1953	8.397	1983	16.820
1924	1.162	1954	8.743	1984	18.230
1925	1.210	1955	9.405	1985	17.200
1926	1.336	1956	10.082	1986	16.790
1927	1.471	1957	10.680	1987	17.350
1928	1.596	1958	11.030	1988	17.810
1929	1.952	1959	12.046	1989	17.870

Source: Bureau of the Census. 1976. Historical Statistics of the United States: Colonial Times to 1970, series M 147. Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 71, p. 161. DOE/EIA-0384(89). Washington, D.C.

Notes: Production data are for marketed production which includes extraction loss and transfers to natural gas plant liquids.

Table 20.--U.S. production of electricity, by energy source, 1950-1990.

(billion kilowatthours)

Year	Coal	Natural gas	Petro-leum	Nuclear power	Hydro-electric	Geo-thermal & other	Total
1950	155	45	34	0	96	<1	329
1955	301	95	37	0	113	<1	547
1960	403	158	48	1	146	<1	756
1961	422	169	49	2	152	<1	794
1962	450	184	49	2	169	<1	855
1963	494	202	52	3	166	<1	917
1964	526	220	57	3	177	<1	984
1965	571	222	65	4	194	<1	1,055
1966	613	251	79	6	195	1	1,144
1967	630	265	89	8	222	1	1,214
1968	685	304	104	13	222	1	1,329
1969	706	333	138	14	250	1	1,442
1970	704	373	184	22	248	1	1,532
1971	713	374	220	38	266	1	1,613
1972	771	376	274	54	273	2	1,750
1973	848	341	314	83	272	2	1,861
1974	828	320	301	114	301	3	1,867
1975	853	300	289	173	300	3	1,918
1976	944	295	320	191	284	4	2,038
1977	985	306	358	251	220	4	2,124
1978	976	305	365	276	280	3	2,206
1979	1,075	329	304	255	280	4	2,247
1980	1,162	346	246	251	276	6	2,286
1981	1,203	346	206	273	261	6	2,295
1982	1,192	305	147	283	309	5	2,241
1983	1,259	274	144	294	332	6	2,310
1984	1,342	297	120	328	321	9	2,416
1985	1,402	292	100	384	281	11	2,470
1986	1,386	249	137	414	291	12	2,487
1987	1,464	273	118	455	250	12	2,572
1988	1,541	253	149	527	223	12	2,704
1989	1,551	253	158	529	264	11	2,779
1990	1,561	249	130	550	315	i	2,795

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 88, p. 203. DOE/EIA/038(89). Washington, D.C.

U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Outlook 1990 with Projections to 2010, table A6, p. 45. DOE/EIA-0383(90). Washington, D.C.

Notes: Other includes wood, waste, photovoltaic, and solar thermal energy. Data for 1990 are projections. i=included under hydroelectric.

Table 21.–Nuclear energy, 1957-1990.

Year	Uranium production (million pounds of U3O8)	Nuclear generating units (number)
1957	16.96	1
1958	24.88	1
1959	32.48	1
1960	35.28	3
1961	34.70	3
1962	34.02	5
1963	28.44	6
1964	23.70	6
1965	20.88	6
1966	21.18	8
1967	22.51	10
1968	24.74	11
1969	23.22	14
1970	25.81	18
1971	24.55	21
1972	25.80	29
1973	26.47	39
1974	23.06	48
1975	23.20	54
1976	25.49	61
1977	29.88	65
1978	36.97	70
1979	37.47	68
1980	43.70	70
1981	38.47	74
1982	26.87	77
1983	21.16	80
1984	14.88	86
1985	11.31	95
1986	13.51	100
1987	12.99	107
1988	13.13	108
1989	13.80	110
1990	na	110

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual energy review 1989, table 98, p. 225. DOE/EIA-0384(89). Washington, D.C.

Federal Power Commission, Form 4, "Monthly Power Plant Report (1957-1972)." Washington, D.C.

Nuclear Regulatory Commission, Report NUREG-0020, Licensed Operating Reactors, monthly (after 1972). Washington, D.C.

Notes: Data on lisensed operating nuclear reactors are current as of February 28, 1990. na=not available.

Table 22.--U.S. energy imports and exports (net), by source, 1950-1989.

(net imports, in quadrillion Btu)

Year	Coal	Natural gas	Petroleum	Other	Total
1950	-0.78	-0.03	1.24	0.03	0.47
1955	-1.46	-0.02	1.98	0.04	0.54
1960	-1.02	0.15	3.57	0.04	2.74
1965	-1.37	0.44	5.01	-0.02	4.06
1966	-1.35	0.47	5.21	-0.01	4.32
1967	-1.35	0.50	4.91	-0.02	4.04
1968	-1.37	0.58	5.73	-0.02	4.90
1969	-1.53	0.70	6.42	-0.02	5.56
1970	-1.93	0.77	6.92	-0.04	5.72
1971	-1.54	0.88	8.07	<0.005	7.41
1972	-1.53	0.97	9.83	0.05	9.32
1973	-1.42	0.98	12.98	0.14	12.68
1974	-1.57	0.91	12.66	0.19	12.19
1975	-1.74	0.90	12.51	0.08	11.75
1976	-1.57	0.92	15.20	0.09	14.65
1977	-1.40	0.98	18.24	0.20	18.02
1978	-1.00	0.94	17.06	0.33	17.32
1979	-1.70	1.24	16.93	0.27	16.75
1980	-2.39	0.96	13.50	0.18	12.25
1981	-2.92	0.86	11.38	0.33	9.65
1982	-2.77	0.90	9.05	0.28	7.46
1983	-2.01	0.89	9.08	0.36	8.31
1984	-2.13	0.79	9.89	0.40	8.96
1985	-2.39	0.90	8.95	0.41	7.87
1986	-2.19	0.69	11.53	0.35	10.38
1987	-2.05	0.94	12.53	0.48	11.90
1988	-2.45	1.22	14.01	0.36	13.15
1989	-2.58	1.31	15.15	0.14	14.02

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 5, p. 15. DOE/EIA-0384(89). Washington, D.C.

Notes: Net imports=imports minus exports. Other includes coal coke and small amounts of electricity transmitted across U.S. borders with Canada and Mexico. Sum of components may not equal totals because of independent rounding.

Table 23.--U.S. energy consumption, by end use sector, 1950-1989.

(quadrillion Btu)

Year	Residential & commercial	Industrial	Transportation	Total
1950	8.87	15.71	8.49	33.08
1955	10.41	18.86	9.55	38.82
1960	13.04	20.16	10.60	43.80
1961	13.44	20.25	10.77	44.46
1962	14.27	21.04	11.23	46.53
1963	14.71	21.95	11.66	48.32
1964	15.23	23.27	12.00	50.50
1965	16.03	24.22	12.43	52.68
1966	17.06	25.50	13.10	55.66
1967	18.10	25.72	13.75	57.57
1968	19.23	26.90	14.86	61.00
1969	20.59	28.10	15.50	64.19
1970	21.71	28.63	16.09	66.43
1971	22.59	28.57	16.72	67.89
1972	23.69	29.86	17.71	71.26
1973	24.14	31.53	18.60	74.28
1974	23.72	30.62	18.12	72.54
1975	23.90	28.40	18.25	70.55
1976	25.02	30.24	19.10	74.36
1977	25.39	31.08	19.82	76.29
1978	26.09	31.39	20.61	78.09
1979	25.81	32.61	20.47	78.90
1980	25.65	30.61	19.69	75.96
1981	25.24	29.24	19.51	73.99
1982	25.63	26.14	19.07	70.85
1983	25.63	25.75	19.13	70.52
1984	26.50	27.73	19.87	74.10
1985	29.73	27.12	20.10	73.95
1986	26.83	26.64	20.76	74.24
1987	27.62	27.87	21.36	76.84
1988	29.00	29.10	22.19	80.20
1989	29.61	29.47	22.15	81.23

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 4, p. 13. DOE/EIA-0384(89). Washington, D.C.

Notes: Includes those fossil fuels consumed directly in the sector, utility electricity sales to the sector, and energy losses in the conversion and transmission of electricity. Conversion and transmission losses are allocated to sectors in proportion to electricity sales to sectors.

Table 24.--U.S. energy consumption, per capita, 1950-1990.

(million Btu)

Year	Total energy
1950	219
1951	230
1952	226
1953	228
1954	218
1955	235
1956	240
1957	236
1958	232
1959	238
1960	244
1961	243
1962	250
1963	256
1964	264
1965	272
1966	285
1967	292
1968	306
1969	319
1970	327
1971	328
1972	340
1973	351
1974	340
1975	327
1976	342
1977	347
1978	352
1979	351
1980	335
1981	322
1982	305
1983	301
1984	313
1985	310
1986	308
1987	316
1988	326
1989	327
1990	341

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 7, p. 23. DOE/EIA/0384(89). Washington, D.C.

Note: Data for 1990 are projections.

Table 25.--U.S. energy consumption, per dollar of GNP, 1950-1989.

(thousand Btu per 1982 dollar)

Year	Petroleum & natural gas	Other energy	Total
1950	16.02	11.46	27.48
1951	16.17	10.53	28.70
1952	16.31	9.27	25.58
1953	16.35	8.92	25.27
1954	17.07	7.84	24.90
1955	17.56	8.41	25.97
1956	18.06	8.41	26.47
1957	18.13	7.97	26.10
1958	18.96	7.25	26.21
1959	19.05	6.81	25.87
1960	19.40	6.90	26.30
1961	19.40	6.62	26.02
1962	19.33	6.53	25.86
1963	19.27	6.52	25.80
1964	19.05	6.54	25.59
1965	18.69	6.55	25.24
1966	18.75	6.46	25.20
1967	19.03	6.31	25.35
1968	19.53	6.26	25.79
1969	20.23	6.26	26.49
1970	21.24	6.26	27.49
1971	21.34	5.98	27.32
1972	21.33	5.99	27.32
1973	20.90	6.17	27.07
1974	20.22	6.36	26.58
1975	19.55	6.63	26.18
1976	19.64	6.67	26.31
1977	19.28	6.50	25.79
1978	18.61	6.46	25.07
1979	18.10	6.61	24.71
1980	17.13	6.70	23.83
1981	15.96	6.81	22.77
1982	15.39	6.98	22.38
1983	14.46	7.05	21.51
1984	14.15	7.01	21.16
1985	13.47	6.96	20.43
1986	13.15	6.81	19.97
1987	13.13	6.81	19.94
1988	13.11	6.81	19.93
1989	12.92	6.69	19.60

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 8, p. 25. DOE/EIA/0384(89). Washington, D.C.

Table 26.--U.S. manufacturing sector energy efficiency, by industry group, 1980 and 1985.

SIC code	Industry group	Energy efficiency ratios 1980	Energy efficiency ratios 1985	Change (percent)
20	Food & kindred products	3.5	2.7	22.9
22	Textile mill products	5.7	4.8	16.3
25	Furniture & fixtures	1.9	1.6	17.4
26	Paper & allied products	16.0	13.9	13.0
27	Printing & publishing	1.1	0.9	15.2
28	Chemicals & allied products	15.1	12.4	17.6
29	Petroluem & coal products	5.4	4.4	19.8
30	Rubber & plastics products	4.3	3.1	27.8
32	Stone, clay & glass products	21.6	16.6	23.0
33	Primary metals industries	16.4	14.6	11.0
34	Fabricated metal products	2.8	2.3	16.4
35	Machinery, except electrical	1.7	0.9	43.6
36	Electrical & electronic equipment	1.7	1.2	26.4
37	Transportation equipment	1.5	1.1	25.0
38	Instruments & related products	1.7	1.2	29.3
39	Misc. manufacturing industries	1.8	1.4	23.9
	All manufacturing	5.8	4.4	25.1

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 16, p. 39. DOE/EIA/0384(89). Washington, D.C.

Notes: Energy efficiency ratios=thousand Btu per constant (1980) dollar value of shipments and receipts. A decrease in the energy efficiency ratio results in an increase in energy efficiency represented by a positive value.

Table 27.–Personal vehicle travel and fuel consumption, 1970-1989.

Year	Personal passenger vehicle travel (miles per capita)	Fuel consumption (gallons per capita)	Fuel efficiency (miles per gallon)
1970	4,470.62	330.75	13.52
1971	4,653.47	343.60	13.54
1972	4,865.96	363.13	13.40
1973	4,935.97	371.23	13.38
1974	4,710.08	351.10	13.40
1975	4,787.47	353.97	13.50
1976	4,945.03	365.50	13.50
1977	5,036.52	365.04	13.88
1978	5,150.76	366.87	14.00
1979	4,948.19	343.48	14.40
1980	4,880.56	315.61	15.50
1981	4,913.65	308.31	15.90
1982	5,015.72	301.31	16.70
1983	5,102.31	297.73	17.10
1984	5,168.43	289.95	17.80
1985	5,268.16	289.49	18.20
1986	5,423.83	295.51	18.30
1987	5,594.93	290.08	19.20
1988	5,844.45	292.11	19.87
1989	6,013.64	290.77	20.54

Source: U.S. Department of Transportation, Federal Highway Administration. Highway statistics, annual, table VM-1. Washington, D.C.

Note: Personal passenger vehicles include automobiles and motorcycles in use.

Table 28.–World primary energy production, by source, 1974-1988.

(quadrillion Btu)

Year	Crude oil & natural gas plant liquids	Natural gas	Coal	Hydro-electric power	Nuclear power	Total
1974	122.46	43.76	63.82	14.83	2.87	247.74
1975	117.22	43.90	66.17	15.03	3.85	246.18
1976	127.08	45.68	67.32	15.08	4.52	259.67
1977	132.08	46.88	68.46	15.56	5.40	268.37
1978	132.89	48.24	69.53	16.80	6.41	273.87
1979	138.57	51.57	73.81	17.69	6.67	288.31
1980	133.07	52.79	75.02	18.21	7.51	286.61
1981	125.34	54.21	75.21	18.42	8.47	281.65
1982	119.67	53.74	78.44	18.89	9.28	280.01
1983	119.13	54.06	78.45	19.83	10.62	282.08
1984	122.38	59.12	82.16	20.37	12.81	296.83
1985	120.91	61.37	86.09	20.67	15.15	304.19
1986	126.00	62.56	88.27	20.90	16.29	314.02
1987	127.26	65.58	90.36	21.07	17.64	321.92
1988	132.53	67.13	93.04	21.31	19.06	333.08

Source: U.S. Department of Energy, Energy Information Administration. 1990. Annual Energy Review 1989, table 106, p. 245. DOE/EIA-0384(89). Washington, D.C.

Note: Total excludes wood, waste, geothermal, wind, photovoltaic, and solar thermal.

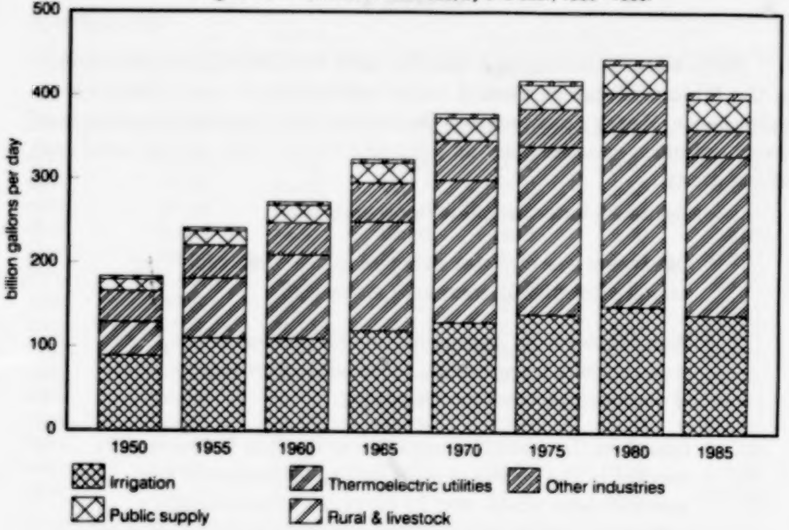
Water

Both water quantity and quality have been monitored extensively in the United States as part of water management and regulatory requirements. Water quality data often reflect the cumulative impacts of many pollution sources such as nonpoint runoff from agricultural and urban areas.

Highlights include the following trends:

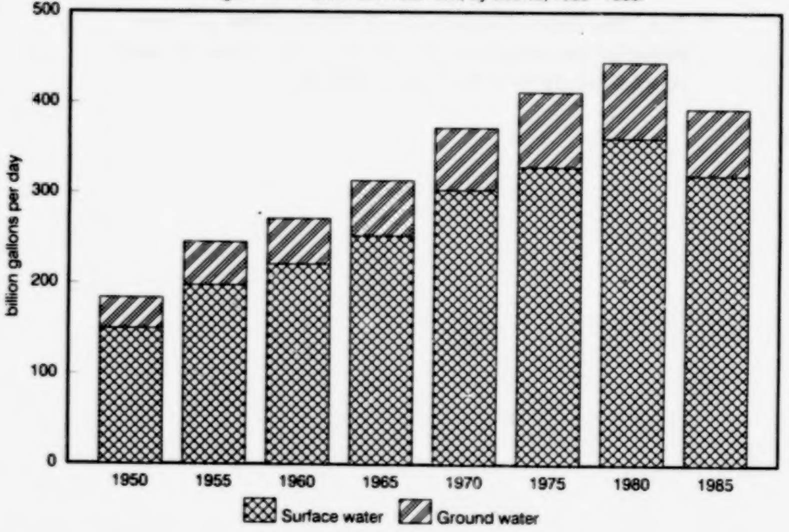
- Offstream use of water dropped in the 1985 reporting period after steady increases since 1900.
- Wastewater from approximately 58 percent of the population is being served by secondary or higher levels of wastewater treatment systems.
- Based on the 1988 National Water Quality Inventory, 70 percent of the assessed river miles, 74 percent of the assessed lake acres, and 72 percent of the assessed estuarine square miles do support state designated uses, such as drinking water supply, contact recreation, and warm and cold water fisheries.
- Shellfishing was prohibited in 1990 in over 4 million acres of shellfish beds off the East Coast and in the Gulf of Mexico.
- The 1989 *Exxon Valdez* oil spill (10.5 million gallons) exceeded the total annual volume of oil spilled in most years since 1976 in the United States.

Figure 15.--Offstream water use, by end user, 1950-1985.



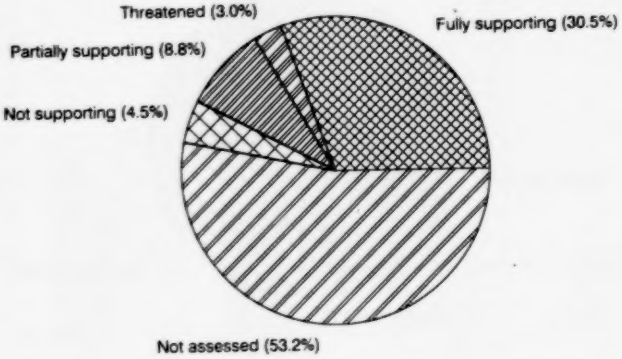
Source: See Table 29.

Figure 16.--Offstream water use, by source, 1950-1985.



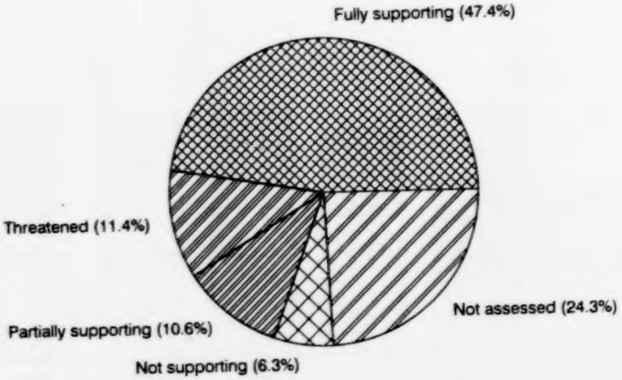
Source: See Table 29.

Figure 17a.--Designated use support in rivers and streams, 1988.



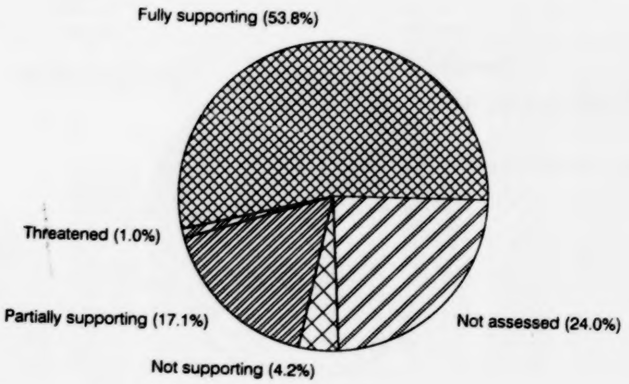
Note: Total river and stream miles = 1,150,482 miles.
Source: See Table 30.

Figure 17b.--Designated use support in lakes and reservoirs, 1988.



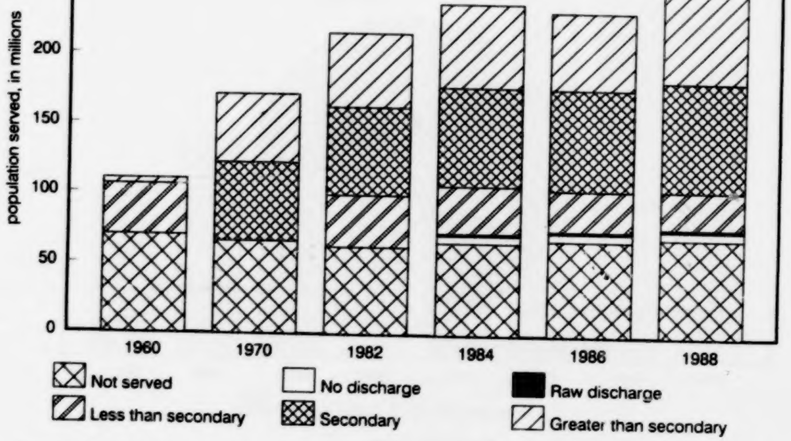
Note: Total lake and reservoir area = 22,486,365 acres.
Source: See Table 30.

Figure 17c.--Designated use support in estuaries, 1988.



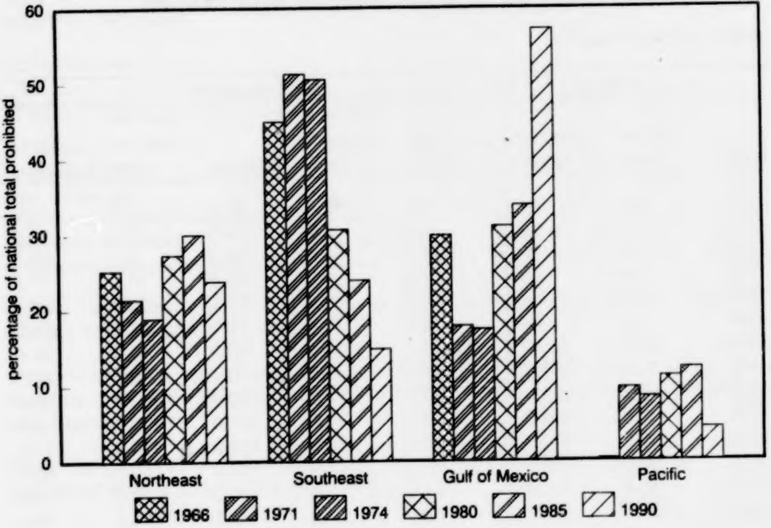
Note: Total estuary area = 35,198 square miles.
Source: See Table 30.

Figure 18.--Population served by wastewater treatment systems, by level of treatment, 1960-1988.



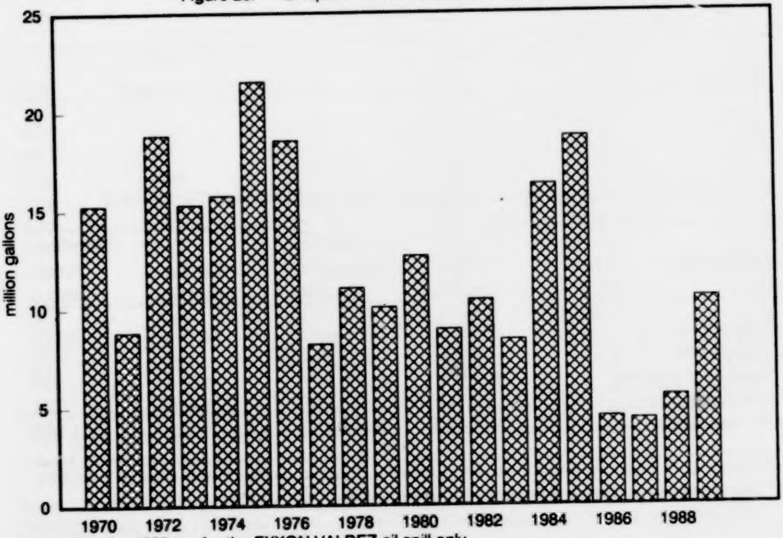
Source: See Table 31.

Figure 19.--Shellfish bed closures, by region, 1966-1990.



Source: See Table 33.

Figure 20.--Oil spills in and around U.S. waters, 1970-1989.



Note: Data for 1989 are for the EXXON VALDEZ oil spill only.
Source: See Table 34.

Table 29.--Offstream water use, by source and end use sector, 1900-1985.

(billion gallons per day)

	Source		End use sector				
Year	Ground water	Surface water	Public supply	Rural & domestic livestock	Irrigation	Thermo-electric utility	Other industries
1900	na	na	3.0	2.0	20.0	5.0	10.0
1910	na	na	5.0	2.2	39.0	7.0	14.0
1920	na	na	6.0	2.4	56.0	9.0	18.0
1930	na	na	8.0	2.9	60.0	18.0	21.0
1940	na	na	10.0	3.1	71.0	23.0	29.0
1945	na	na	12.0	3.4	80.0	31.5	35.0
1950	34.0	150.0	14.0	3.6	89.0	40.0	37.0
1955	47.6	198.0	17.0	3.6	110.0	72.0	39.0
1960	50.4	221.0	21.0	3.6	110.0	100.0	38.0
1965	60.5	253.0	24.0	4.0	120.0	130.0	46.0
1970	69.0	303.0	27.0	4.5	130.0	170.0	47.0
1975	83.0	329.0	29.0	4.9	140.0	200.0	45.0
1980	83.9	361.0	34.0	5.6	150.0	210.0	45.0
1985	73.7	320.0	37.0	7.8	140.0	190.0	31.0

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical Statistics of the United States: Colonial Times to 1970, series J 92-103. Washington, D.C.

Solley, W.B., C.F. Merk & R.R. Pierce. 1988. Estimated Use of Water in the United States in 1985. U.S. Department of the Interior, Geological Survey Circular 1004, and earlier reports in this series. Reston, VA.

Note: na=not available.

Table 30.--Designated use support in surface waters of the United States, 1988.

Designated use	Rivers & streams (miles)	Lakes & reservoirs (acres)	Estuaries (sq. mi.)	Nearshore ocean (miles)
Fully supporting	361,332	12,021,044	19,110	3,324
Threatened	36,038	2,897,711	350	73
Partially supporting	104,632	2,701,577	6,078	307
Not supporting	53,449	1,591,391	1,488	124
Not assessed	631,069	6,172,353	8,522	1,393

Source: U.S. Environmental Protection Agency. 1990. National Water Quality Inventory: 1988 report to Congress. EPA 440-4-90-003. Washington, D.C.

Table 31.--Population served by wastewater treatment systems, by level of treatment, 1960-1988.

(million people)

Level of treatment	1960	1978	1982	1984	1986	1988
Not served	70.0	68.0	62.0	65.7	67.8	69.9
No discharge	na	na	na	5.5	5.7	6.1
Raw discharge	na	na	na	1.3	1.6	1.5
Less than secondary treatment	36.0	na	37.0	33.7	28.8	26.5
Secondary treatment	na	56.0	63.0	70.7	72.3	78.0
Greater than secondary treatment	4.0	49.0	53.0	59.5	54.9	65.7

Source: 1960: Kollar, K.L. 1979. Market for water and wastewater treatment equipment. J. Water Pollution Control Fed. 51:682.

U.S. Environmental Protection Agency, Office of Water. 1990. National water quality inventory: 1988 report to Congress, and earlier reports in this series. EPA 440-4-90-003. Washington, D.C.

Notes: Data for 1960 are not strictly comparable to other data because of different methods of data collection. na=not available.

Table 32.--Estimated phosphorus loadings to the Great Lakes, 1976-1986.

(metric tons)

Year	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
1976	3,550	6,656	4,802	18,480	12,695
1977	3,661	4,666	3,763	14,576	8,935
1978	5,990	6,245	5,255	19,431	9,547
1979	6,619	7,659	4,881	11,941	8,988
1980	6,412	6,574	5,307	14,855	8,579
1981	3,412	4,091	3,481	10,452	7,437
1982	3,160	4,084	4,689	12,349	8,891
1983	3,407	4,515	3,978	9,880	6,779
1984	3,642	3,611	3,452	12,874	7,948
1985	2,864	3,956	5,758	11,216	7,083
1986	3,059	4,981	4,210	11,118	9,561

Source: Great Lakes Water Quality Board. 1989. Great Lakes Water Quality. Surveillance Subcommittee Report to the International Joint Commission, United States and Canada. Windsor, ON.

Note: The 1978 Great Lakes Water Quality Agreement set target loadings for each lake (in metric tons per year): Lake Superior-3,400; Lake Michigan-5,600; Lake Huron-4,360; Lake Erie-11,000; and Lake Ontario-7,000.

Table 33.--Shellfish bed closures, by region, 1966-1990.

(thousands of prohibited acres and percentage of national total prohibited)

Year	Northeast		Southeast		Gulf of Mexico		Pacific	
	Area	Percent	Area	Percent	Area	Percent	Area	Percent
1966	443.1	25.2	790.0	44.9	523.7	29.8	3.4	0.2
1971	710.4	21.4	1,702.4	51.2	592.1	17.8	317.4	9.6
1974	710.8	18.9	1,896.6	50.5	829.1	17.4	316.8	8.4
1980	781.8	27.3	877.9	30.6	889.1	31.0	317.5	11.1
1985	782.1	30.0	625.0	23.9	880.4	33.8	317.8	12.2
1990	1,014.0	23.8	631.0	14.8	2,430.0	57.1	183.0	4.3

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Survey, Ocean Assessments Division, Strategic Assessment Branch. Trends in Harvest-Limited Shellfish Areas (data compiled from the National Estuarine Inventory database). Rockville, MD.

Table 34.--Oil spills in and around U.S. waters, 1970-1989.

Year	Number (thousand spills)	Volume (million gallons)
1970	3.71	15.25
1971	8.74	8.84
1972	9.93	18.81
1973	11.05	15.29
1974	12.08	15.74
1975	11.00	21.53
1976	11.07	18.52
1977	10.98	8.19
1978	12.17	11.04
1979	11.56	10.05
1980	9.89	12.64
1981	9.59	8.92
1982	9.42	10.41
1983	10.53	8.38
1984	10.09	16.26
1985	7.75	18.68
1986	6.54	4.45
1987	6.18	4.33
1988	6.75	5.49
1989	na	10.50

Source: U.S. Department of Transportation, United States Coast Guard. Polluting Incidents In and Around U.S. Waters, annual. COMDTINST M16450 series. Washington, D.C.

Note: na=not available. Volumetric data for 1989 provide an estimate from the EXXON VALDEZ oil spill in Prince William Sound, Alaska only.

Air Quality

Atmospheric emissions may result in environmental impacts over broad geographic areas, from regional to global scales. Therefore both national and international trend data are relevant. Most monitoring of air quality in the United States has been conducted within urban areas to determine compliance with the National Ambient Air Quality Standards (NAAQS) and may not represent the levels of air pollution that forest, agricultural, and other nonurban areas are experiencing. High levels of ambient ozone — the product of photochemical processes acting on nitrogen oxides, volatile organic compounds, and other pollutants — have adverse impacts on the environment and human health. Conversely, the loss of ozone in the stratosphere, miles above the earth, is a concern because of its beneficial role as a screen from the sun's harmful ultraviolet rays.

Highlights include the following trends:

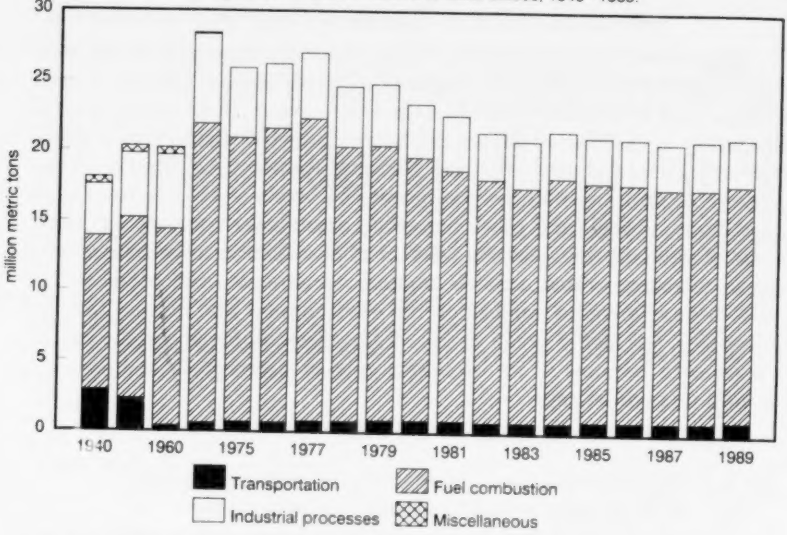
- Despite increases in population and economic output, national anthropogenic emissions of criteria air pollutants (sulfur dioxide, nitrogen oxides, ozone, particulate matter, carbon monoxide, and lead) have declined since the mid-1970s.

- Ambient concentrations of criteria air pollutants have also declined since the mid-1970s, with the exception of ambient ozone.

- Levels of sulfate ion in wet deposition, one of the main constituents of acid rain, have declined since 1982.

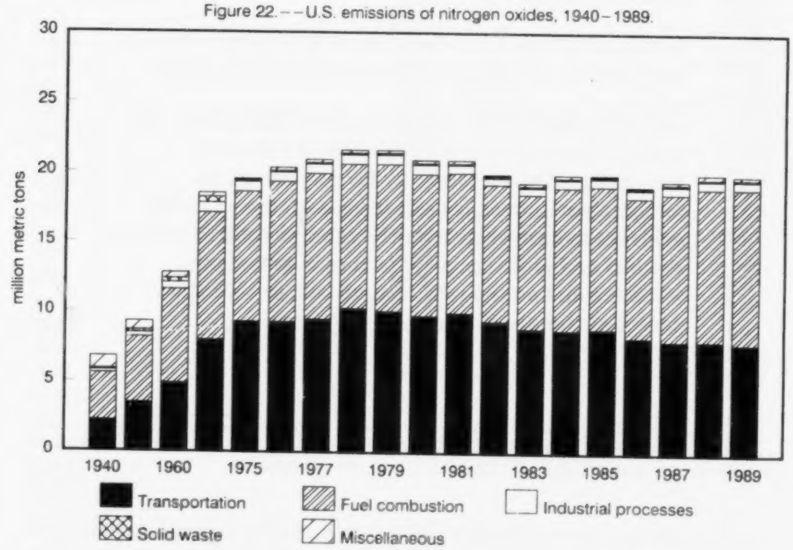
- Global emissions and atmospheric concentrations of carbon dioxide and other greenhouse gases are increasing. While a tendency for positive global temperature anomalies has increased, the scientific evidence is inconclusive on the relative contribution of natural and anthropogenic factors to greenhouse warming and on the rate, magnitude, or timing of potential climate change.

Figure 21.--U.S. emissions of sulfur oxides, 1940-1989.



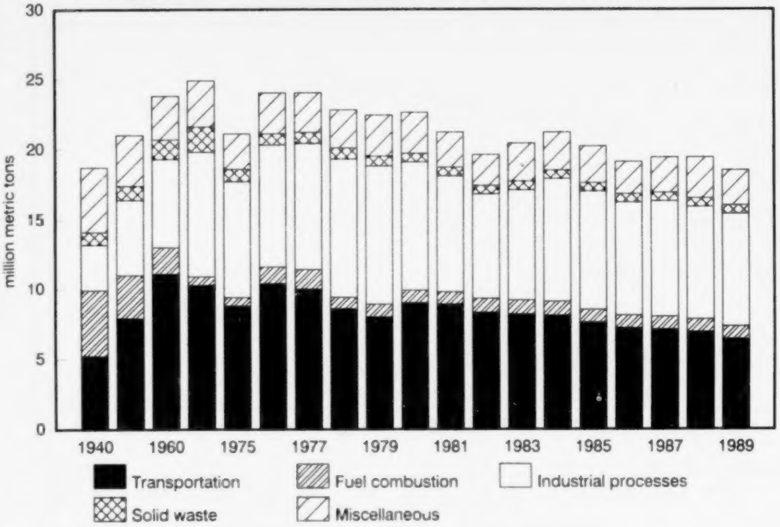
Source: See Table 39.

Figure 22.--U.S. emissions of nitrogen oxides, 1940-1989.



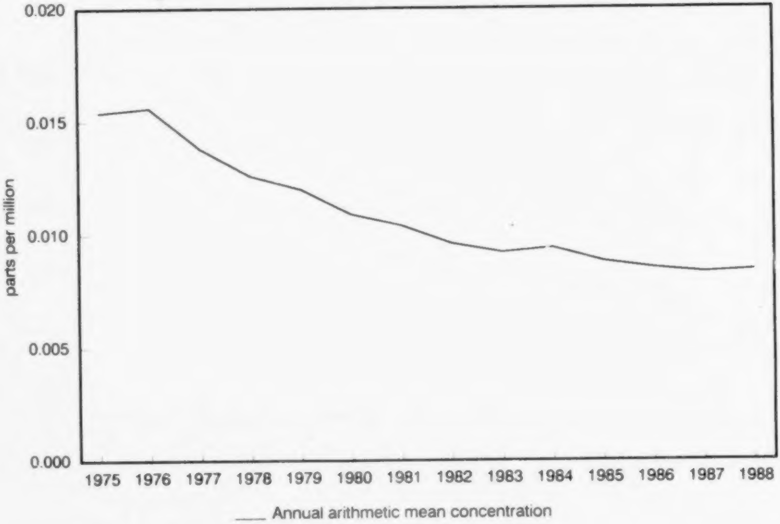
Source: See Table 39.

Figure 23.--U.S. emissions of reactive volatile organic compounds, 1940-1989.



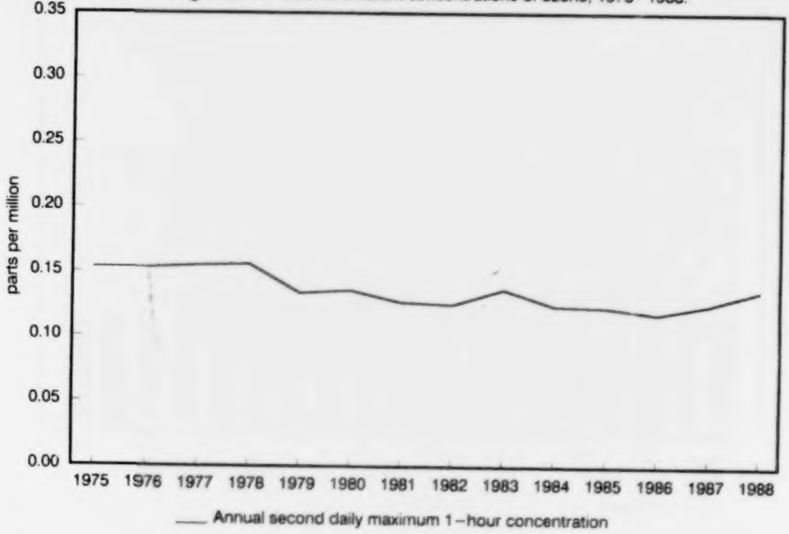
Source: See Table 39.

Figure 24.--National ambient concentrations of sulfur dioxide, 1975-1988.



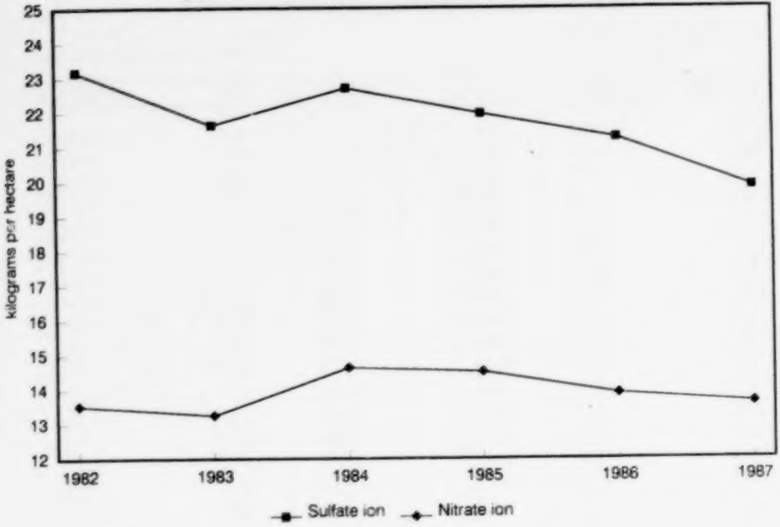
Source: See Table 40.

Figure 25.--National ambient concentrations of ozone, 1975-1988.



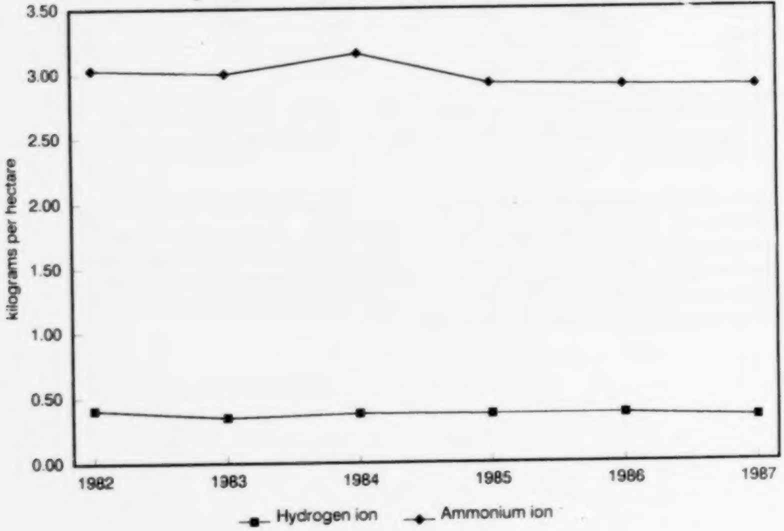
Source: See Table 40.

Figure 26a.--Wet deposition of selected pollutants, 1982-1987.



Source: See Table 41.

Figure 26b.--Wet deposition of selected pollutants, 1982-1987.



Source: See Table 41.

Table 35.--Annual global surface temperature anomalies, 1900-1988.

(degrees Celsius)

Year	Variation	Year	Variation	Year	Variation
1900	0.01	1930	-0.03	1960	0.00
1901	-0.08	1931	0.05	1961	0.11
1902	-0.17	1932	-0.01	1962	0.10
1903	-0.30	1933	-0.11	1963	0.11
1904	-0.39	1934	-0.02	1964	-0.15
1905	-0.25	1935	-0.06	1965	-0.12
1906	-0.15	1936	-0.02	1966	-0.02
1907	-0.35	1937	0.10	1967	-0.04
1908	-0.34	1938	0.14	1968	-0.08
1909	-0.25	1939	0.04	1969	0.08
1910	-0.25	1940	0.04	1970	0.05
1911	-0.30	1941	0.07	1971	-0.10
1912	-0.21	1942	0.01	1972	0.02
1913	-0.21	1943	0.00	1973	0.15
1914	-0.09	1944	0.15	1974	-0.11
1915	0.00	1945	0.06	1975	-0.08
1916	-0.21	1946	-0.08	1976	-0.21
1917	-0.40	1947	-0.05	1977	0.10
1918	-0.29	1948	-0.06	1978	0.03
1919	-0.16	1949	-0.06	1979	0.12
1920	-0.17	1950	-0.13	1980	0.18
1921	-0.12	1951	-0.02	1981	0.24
1922	-0.20	1952	0.07	1982	0.09
1923	-0.18	1953	0.11	1983	0.31
1924	-0.19	1954	-0.13	1984	0.10
1925	-0.12	1955	-0.14	1985	0.07
1926	0.07	1956	-0.23	1986	0.16
1927	-0.04	1957	0.07	1987	0.33
1928	-0.05	1958	0.12	1988	0.34
1929	-0.22	1959	0.05		

Source: The Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory. 1990. Trends '90: A Compendium of Data on Global Change, p. 195. Oak Ridge, TN.

Note: Global surface temperature anomalies are relative to a 1957-1979 reference period mean. El Nino/Southern Oscillation effects have not been removed. Some climatologists would say that the build-up of greenhouse gases in the atmosphere is the most likely cause of the long-term warming trend, whereas other climatologists would say that the recent warming trend is simply a manifestation of El Nino/Southern Oscillation events in the Pacific.

Table 36.--Global carbon dioxide emissions, from anthropogenic sources, 1950-1988.

(million metric tons of carbon)

Year	Emissions	Year	Emissions
1950	1,638	1970	4,090
1951	1,775	1971	4,241
1952	1,803	1972	4,409
1953	1,848	1973	4,647
1954	1,871	1974	4,655
1955	2,050	1975	4,628
1956	2,185	1976	4,894
1957	2,278	1977	5,033
1958	2,338	1978	5,082
1959	2,471	1979	5,365
1960	2,586	1980	5,263
1961	2,602	1981	5,129
1962	2,708	1982	5,093
1963	2,855	1983	5,084
1964	3,016	1984	5,260
1965	3,154	1985	5,379
1966	3,314	1986	5,561
1967	3,420	1987	5,680
1968	3,595	1988	5,893
1969	3,809		

Source: The Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory. 1990. Trends '90: A Compendium of Data on Global Change, p. 93. Oak Ridge, TN.

Note: Emissions from anthropogenic sources include emissions from fossil fuel consumption, cement manufacturing, and gas flaring.

Table 37.–Atmospheric concentrations of carbon dioxide, 1958-1989.

(parts per million by volume)

Year	Mauna Loa, Hawaii	South Pole	American Samoa	Point Barrow, Alaska
1958	315.6	314.5	na	na
1959	316.1	315.5	na	na
1960	317.0	316.9	na	na
1961	317.7	317.7	na	na
1962	318.6	317.3	na	na
1963	319.1	318.1	na	na
1964	319.6	318.3	na	na
1965	320.4	319.3	na	na
1966	321.1	320.6	na	na
1967	322.0	321.3	na	na
1968	322.8	321.6	na	na
1969	324.2	322.4	na	na
1970	325.5	324.1	na	na
1971	326.5	324.8	na	na
1972	327.6	325.9	na	na
1973	329.8	327.4	na	327.9
1974	330.4	328.3	na	332.6
1975	331.0	329.3	na	333.3
1976	332.1	330.4	330.6	333.7
1977	333.6	331.8	332.5	334.7
1978	335.2	333.6	335.3	336.7
1979	336.5	334.8	336.3	337.9
1980	338.4	336.9	338.0	339.9
1981	339.5	338.1	338.3	341.7
1982	340.8	339.3	340.3	342.8
1983	342.8	341.0	341.6	344.1
1984	344.3	342.4	343.3	346.0
1985	345.7	343.7	344.4	347.0
1986	346.9	345.2	345.9	348.7
1987	348.6	346.8	347.6	349.8
1988	351.2	348.9	349.7	352.9
1989	352.8	349.8	na	na

Source: Keeling, C.D. Scripps Institution of Oceanography, La Jolla, CA. (Data provided by the Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN).

Thoning, K.W. Cooperative Institute for Research in Environmental Studies, University of Colorado, Boulder, CO. (Data provided by the Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN).

Notes: na=not available. Data for 1989 are preliminary.

Table 38.--Global annual releases of chlorofluorocarbons, 1931-1988.

(million kilograms)

Year	CFC-11	CFC-12
1931	0.0	0.1
1932	0.0	0.1
1933	0.0	0.1
1934	0.0	0.2
1935	0.0	0.3
1936	0.0	0.5
1937	0.0	0.8
1938	0.1	1.2
1939	0.1	1.7
1940	0.1	2.3
1941	0.1	3.0
1942	0.1	3.7
1943	0.2	4.5
1944	0.2	6.1
1945	0.3	8.0
1946	0.6	13.9
1947	1.3	21.3
1948	2.3	24.8
1949	3.8	26.6
1950	5.5	29.5
1951	7.6	32.4
1952	11.0	33.7
1953	15.0	37.9
1954	18.6	42.9
1955	23.0	48.2
1956	28.7	56.1
1957	32.2	63.8
1958	30.2	66.9
1959	30.9	74.8
1960	40.5	89.1
1961	52.1	99.7
1962	65.4	114.5
1963	80.0	133.9
1964	95.0	155.5
1965	108.3	175.4
1966	121.3	195.0
1967	137.6	219.9
1968	156.8	246.5
1969	181.9	274.3
1970	206.6	299.9
1971	226.9	321.8
1972	255.8	349.9
1973	292.4	387.3
1974	321.4	418.6
1975	310.9	404.1
1976	316.7	390.4
1977	303.9	371.2
1978	283.6	341.3
1979	263.7	337.5
1980	250.8	332.5
1981	248.2	340.7
1982	239.5	337.4
1983	252.8	343.3
1984	271.1	359.4
1985	280.8	368.4
1986	295.1	376.5
1987	310.6	386.5
1988	314.5	392.8

Source: Chemical Manufacturers Association. 1989. Production, Sales, and Calculated Release of CFC-11 and CFC-12 through 1988, table 3. Washington, D.C.

Note: Data are supplied by reporting companies participating in the Chemical Manufacturers Association's chlorofluorocarbon research program.

Table 39.--U.S. emissions of criteria air pollutants, by source, 1940-1989.

(million metric tons)

	Sulfur dioxide					
Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	2.9	11.0	3.7	0.0	0.5	17.6
1950	2.3	12.9	4.6	0.0	0.5	19.8
1960	0.4	14.0	5.3	0.0	0.5	19.7
1970	0.6	21.3	6.4	0.0	0.1	28.3
1975	0.6	20.3	4.7	0.0	0.0	25.6
1976	0.7	20.9	4.6	0.0	0.0	26.2
1977	0.8	21.5	4.7	0.0	0.0	26.9
1978	0.8	19.9	4.3	0.0	0.0	25.0
1979	0.9	19.5	4.4	0.0	0.0	24.8
1980	0.9	18.7	3.8	0.0	0.0	23.4
1981	0.9	17.8	3.9	0.0	0.0	22.6
1982	0.8	17.3	3.3	0.0	0.0	21.4
1983	0.8	16.7	3.3	0.0	0.0	20.7
1984	0.8	17.4	3.3	0.0	0.0	21.5
1985	0.9	17.0	3.2	0.0	0.0	21.1
1986	0.9	16.9	3.2	0.0	0.0	20.9
1987	0.9	16.6	3.2	0.0	0.0	20.7
1988	0.9	16.6	3.4	0.0	0.0	20.9
1989	1.0	16.8	3.3	0.0	0.0	21.1

	Nitrogen oxides					
Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	2.2	3.4	0.2	0.1	0.9	6.8
1950	3.5	4.7	0.3	0.2	0.6	9.3
1960	4.9	6.7	0.5	0.3	0.4	12.8
1970	7.6	9.1	0.7	0.4	0.3	18.1
1975	8.9	9.4	0.7	0.1	0.1	19.2
1976	9.3	10.0	0.7	0.1	0.2	20.3
1977	9.5	10.4	0.7	0.1	0.2	20.9
1978	10.3	10.3	0.7	0.1	0.2	21.7
1979	10.1	10.5	0.7	0.1	0.2	21.6
1980	9.8	10.1	0.7	0.1	0.2	20.9
1981	10.0	10.0	0.6	0.1	0.2	20.9
1982	9.4	9.8	0.5	0.1	0.1	20.0
1983	8.9	9.6	0.5	0.1	0.2	19.3
1984	8.8	10.2	0.6	0.1	0.2	19.8
1985	8.9	10.2	0.6	0.1	0.1	19.8
1986	8.3	10.0	0.6	0.1	0.1	19.1
1987	8.1	10.5	0.6	0.1	0.2	19.4
1988	8.1	10.9	0.6	0.1	0.3	20.0
1989	7.9	11.1	0.6	0.1	0.2	19.9

continued

Table 39 (continued).--U.S. emissions of criteria air pollutants, by source, 1940-1989.

(million metric tons)

Year	Reactive volatile organic compounds					
	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	5.2	4.7	3.3	0.9	4.6	18.6
1950	7.9	3.1	5.4	1.0	3.6	21.0
1960	11.1	1.9	6.3	1.4	3.1	23.8
1970	12.4	1.1	8.9	1.8	3.3	27.5
1975	10.3	1.0	8.1	0.9	2.5	22.8
1976	10.4	1.2	8.7	0.8	2.9	24.0
1977	10.0	1.4	9.0	0.8	2.8	24.2
1978	8.6	0.8	9.9	0.8	2.7	22.8
1979	8.0	0.9	9.9	0.7	2.9	22.4
1980	9.0	0.9	9.2	0.6	2.9	22.7
1981	8.9	0.9	8.3	0.6	2.5	21.3
1982	8.3	1.0	7.5	0.6	2.2	19.5
1983	8.2	1.0	7.9	0.6	2.7	20.3
1984	8.1	1.0	8.8	0.6	2.7	21.1
1985	7.6	0.9	8.5	0.6	2.6	20.2
1986	7.2	0.9	8.1	0.6	2.3	19.1
1987	7.1	0.9	8.3	0.6	2.5	19.4
1988	6.9	0.9	8.1	0.6	2.9	19.5
1989	6.4	0.9	8.1	0.6	2.5	18.5

Year	Total suspended particulates					
	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	2.7	7.5	8.7	0.5	3.7	23.1
1950	2.1	7.0	12.7	0.6	2.5	24.9
1960	0.7	5.7	12.5	0.9	1.8	21.6
1970	1.2	4.6	10.5	1.1	1.1	18.5
1975	1.4	2.7	5.0	0.6	0.7	10.6
1976	1.4	2.5	4.4	0.4	1.0	9.7
1977	1.4	2.5	4.0	0.4	0.8	9.1
1978	1.4	2.5	4.0	0.4	0.8	9.1
1979	1.4	2.5	3.8	0.4	0.9	8.9
1980	1.3	2.4	3.3	0.4	1.1	8.5
1981	1.3	2.3	3.0	0.4	0.9	8.0
1982	1.3	2.2	2.6	0.3	0.7	7.1
1983	1.3	2.0	2.4	0.3	1.1	7.1
1984	1.3	2.1	2.8	0.3	0.9	7.4
1985	1.4	1.8	2.8	0.3	1.1	7.3
1986	1.4	1.8	2.5	0.3	0.9	6.8
1987	1.4	1.8	2.5	0.3	1.0	7.0
1988	1.5	1.7	2.7	0.3	1.3	7.5
1989	1.5	1.8	2.7	0.3	1.0	7.2

continued

Table 39 (continued).--U.S. emissions of criteria air pollutants, by source, 1940-1989.

(million metric tons)

	Carbon monoxide					
Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1940	29.3	15.9	6.6	3.3	28.5	81.6
1950	43.6	11.4	10.5	4.3	16.5	86.3
1960	57.0	7.0	9.3	5.1	10.0	88.4
1970	74.4	4.5	8.9	6.4	7.2	101.4
1975	65.0	4.3	6.9	3.1	4.8	84.1
1976	64.3	4.7	7.1	2.7	7.1	85.9
1977	61.0	5.1	7.3	2.6	5.8	81.8
1978	63.1	5.9	7.2	2.5	5.7	84.4
1979	59.1	6.7	7.1	2.3	6.5	81.7
1980	56.1	7.4	6.3	2.2	7.6	79.6
1981	55.4	7.7	5.9	2.1	6.4	77.4
1982	52.9	8.2	4.3	2.0	4.9	72.4
1983	52.4	8.2	4.3	1.9	7.7	74.5
1984	50.6	8.3	4.7	1.9	6.3	71.8
1985	47.9	7.5	4.4	1.9	7.9	69.5
1986	44.6	7.5	4.2	1.8	5.9	64.0
1987	43.3	7.6	4.3	1.8	7.2	64.2
1988	41.2	7.6	4.6	1.7	9.9	65.0
1989	40.0	7.8	4.6	1.7	6.7	60.9

(thousand metric tons)

	Lead					
Year	Transportation	Fuel combustion	Industrial processes	Solid waste	Miscellaneous	Total
1970	163.6	9.6	23.9	6.7	0.0	203.8
1975	122.6	9.3	10.3	4.8	0.0	147.0
1976	132.4	8.3	8.1	4.3	0.0	153.1
1977	124.2	7.2	5.7	4.1	0.0	141.2
1978	112.4	6.1	5.4	4.0	0.0	127.9
1979	94.6	4.9	5.2	4.0	0.0	108.7
1980	59.4	3.9	3.6	3.7	0.0	70.6
1981	46.9	2.8	3.0	3.7	0.0	56.4
1982	46.9	1.7	2.7	3.1	0.0	54.4
1983	40.8	0.6	2.4	2.6	0.0	46.4
1984	34.7	0.5	2.3	2.6	0.0	40.1
1985	15.5	0.5	2.3	2.6	0.0	20.9
1986	3.5	0.5	1.9	2.6	0.0	8.4
1987	3.0	0.5	1.9	2.6	0.0	8.0
1988	2.6	0.5	2.0	2.5	0.0	7.6
1989	2.2	0.5	2.0	2.3	0.0	7.2

Source: U.S. Environmental Protection Agency. 1991. National Air Quality and Emissions Trends Report, 1989. EPA-450/4-91-003. Research Triangle Park, NC.

Table 40.--National ambient concentrations of criteria air pollutants, 1975-1988.

Year	Sulfur dioxide (ppm)	Carbon monoxide (ppm)	Ozone (ppm)	Nitrogen dioxide (ppm)	TSP (ug/m3)	Lead (mg/m3)
1975	0.0154	11.96	0.153	0.029	61.9	1.04
1976	0.0156	11.32	0.153	0.029	62.8	1.05
1977	0.0138	10.66	0.155	0.029	62.9	1.16
1978	0.0126	10.07	0.156	0.029	62.4	1.04
1979	0.0120	9.07	0.134	0.026	63.1	0.77
1980	0.0109	8.52	0.136	0.025	64.2	0.61
1981	0.0104	8.25	0.127	0.025	60.3	0.48
1982	0.0096	7.86	0.125	0.024	50.1	0.49
1983	0.0092	7.77	0.137	0.024	49.7	0.39
1984	0.0094	7.72	0.124	0.024	51.2	0.35
1985	0.0088	7.03	0.123	0.024	48.8	0.23
1986	0.0085	7.00	0.118	0.024	48.6	0.13
1987	0.0083	6.84	0.125	0.024	49.7	0.10
1988	0.0084	6.56	0.136	0.024	50.5	0.08

Source: U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 1990. National Air Quality and Emissions Trends Report, 1988. EPA-450/4-90-002 Research Triangle Park, NC.

Notes: ppm=parts per million. ug/m3=micrograms per cubic meter. mg/m3=milligrams per cubic meter. TSP=total suspended particulates. Sulfur dioxide and nitrogen dioxide records are arithmetic means. Carbon monoxide and ozone records are second maximum readings over 8- and 24- hour periods, respectively. TSP records are geometric means. Lead records are maximum quarterly recordings. Data represent composite averages from all sites in the nationwide monitoring network.

Table 41.--Wet deposition of selected pollutants, 1982-1987.

(kilograms per hectare)

Year	Hydrogen ion	Sulfate ion	Nitrate ion	Ammonium ion	Calcium ion
1982	0.41	23.17	13.54	3.03	1.90
1983	0.35	21.63	13.26	3.00	2.04
1984	0.38	22.69	14.63	3.15	2.06
1985	0.37	21.95	14.51	2.92	1.81
1986	0.37	21.26	13.89	2.90	1.60
1987	0.34	19.85	13.62	2.89	1.65

Source: Sisterson, D.L. et al. 1990. Deposition Monitoring: Methods and Results. NAPAP SOS/T State of Science and Technology Report 6. IN: National Acid Deposition Assessment Program, State of Science and Technology, vol. 1, table 6-22, p. 14. Washington, D.C.

Note: Data represent the summary of 1982-1987 trend sites (n=148) annual deposition by year. Means are reported.

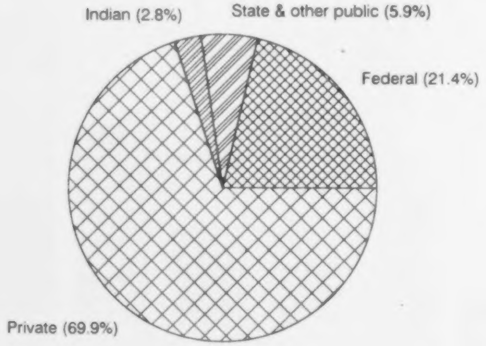
Land, Agriculture, and Forestry

Trends of land use are of interest because many environmental concerns relate to the adequacy and suitability of habitat. Concerns for protecting wetland areas are directly related to biological diversity. Land conversions, such as some types of urban development, may preclude other uses, now or in the future. In addition, the nation's agricultural and forest productivity depends on having adequate land and managing it in ways that minimize erosion or other natural resource losses.

Highlights include the following trends:

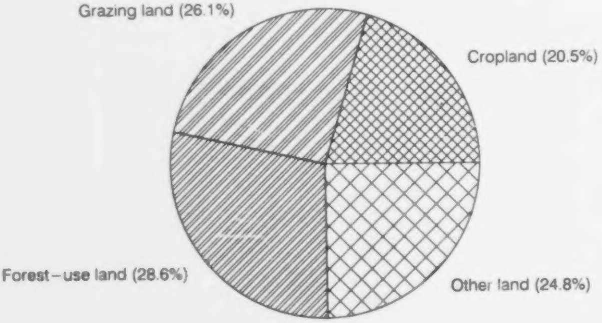
- The total amount of federal land has remained constant over the past three decades, while the allocation of federal land to parks/wilderness and wildlife areas has increased significantly since 1978.
- The area of wetlands in the lower 48 states is currently about 47 percent of that estimated to have existed in the 1780s. Specific types of wetlands, such as the bottomland hardwood forests along the Mississippi River alluvial plain, have declined significantly since data collection was begun in 1937.
- The number of farms, especially small farms, has decreased since the 1940s with an associated increase in the number of large farms.
- Farm fuel use has decreased while the inputs of fertilizer to farmland, the use of chemicals, and the amount of irrigated farmland have remained approximately constant.
- The majority of timberland and net annual growth of timber stocks have been associated with farmer and other private holdings with a disproportionately higher removal of growing stock volume from forest industry and national forest lands.

Figure 27a.--Land ownership in the conterminous United States, 1987.



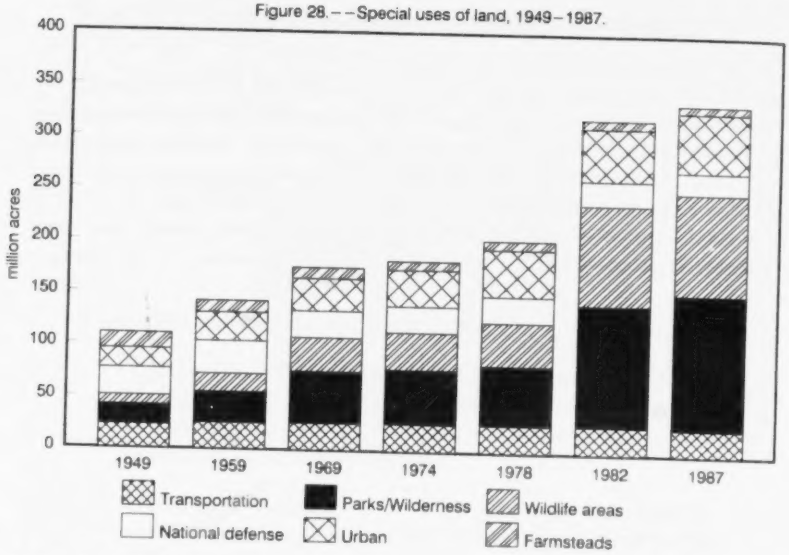
Note: Land area of the conterminous United States = 1,896 million acres. Excludes Alaska and Hawaii.
Source: See Source for Table 43.

Figure 27b.--Major uses of land in the United States, 1987.



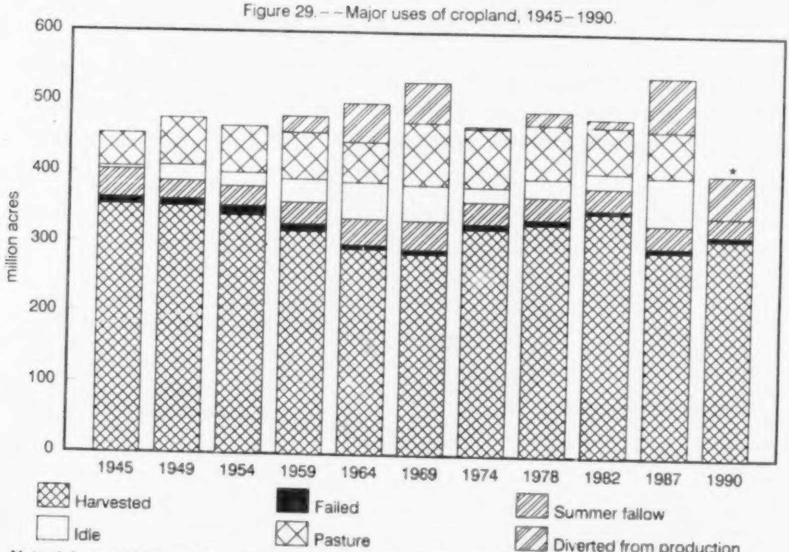
Note: Total land area = 2,265 million acres. Includes Alaska and Hawaii.
Source: See Table 43.

Figure 28.--Special uses of land, 1949-1987.



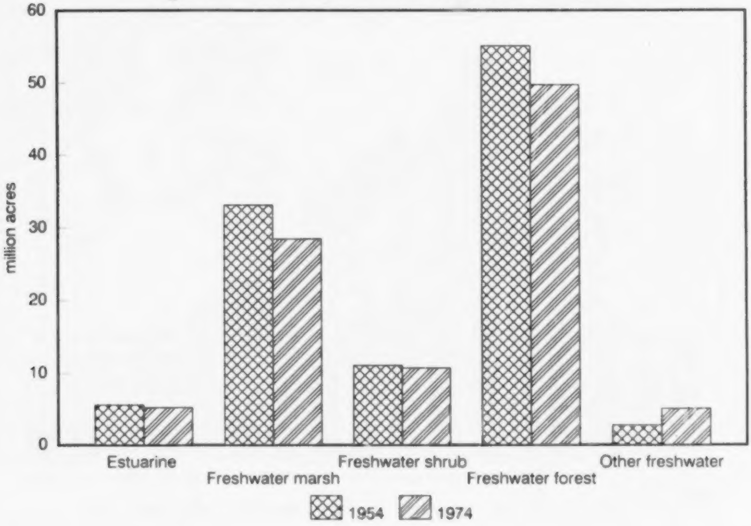
Source: See Table 44.

Figure 29.--Major uses of cropland, 1945-1990.



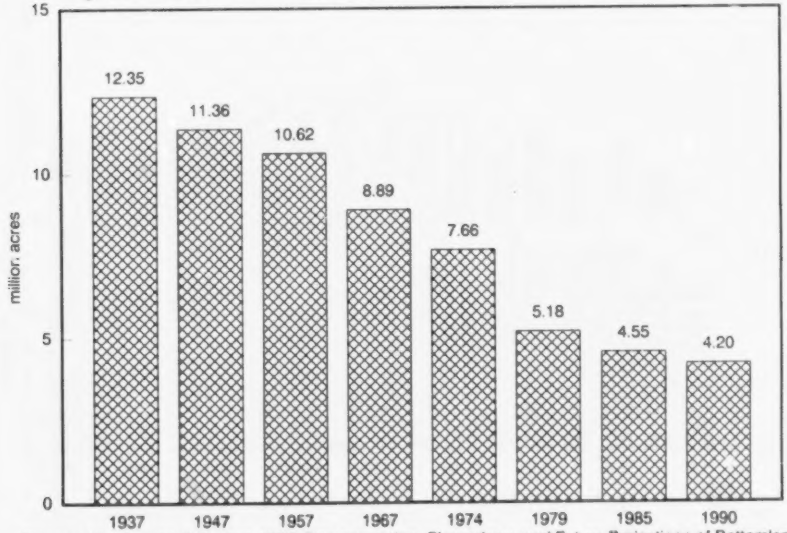
Note: * Acres of idle cropland, cropland pasture, and total cropland not available for 1990.
Source: See Table 50.

Figure 30.--Wetlands in the conterminous United States, 1954-1974.



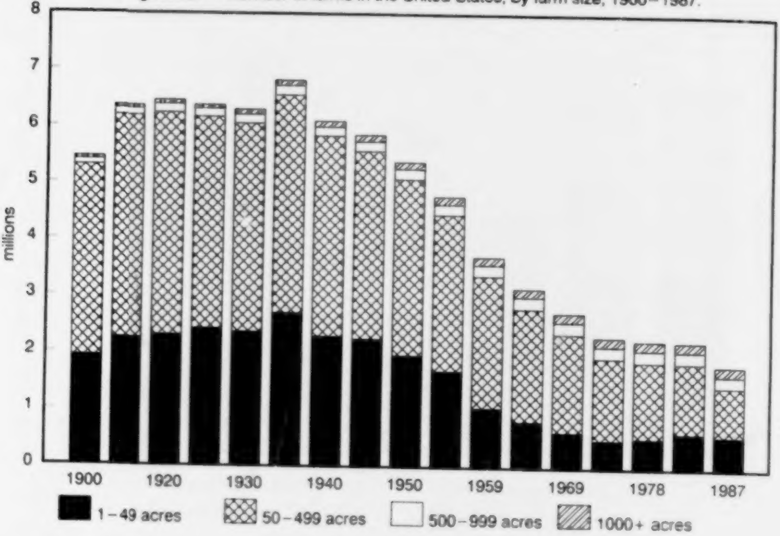
Source: See Table 45.

Figure 31.--Bottomland hardwood forests in the Lower Mississippi alluvial plain, 1937-1990.



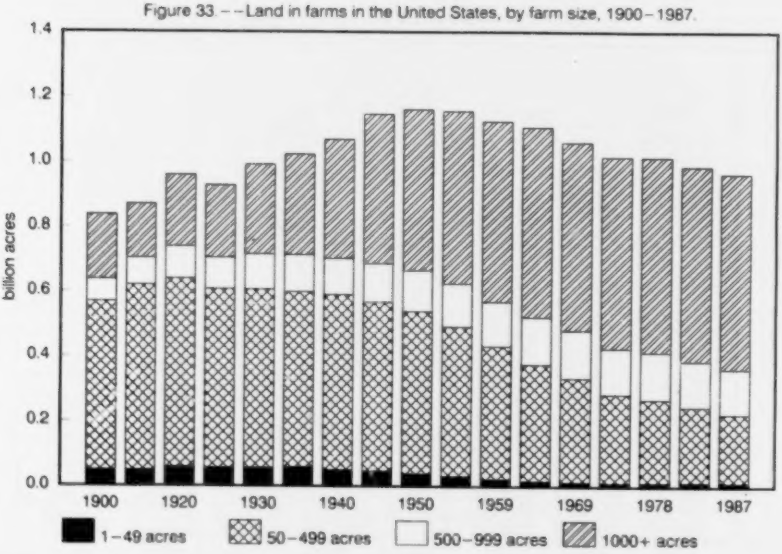
Source: MacDonald, P.O. et al. 1979. Documentation, Chronology, and Future Projections of Bottomland Hardwood Losses in the Lower Mississippi Alluvial Plain. U.S. Fish and Wildlife Service. Washington, D.C.

Figure 32.--Number of farms in the United States, by farm size, 1900-1987.



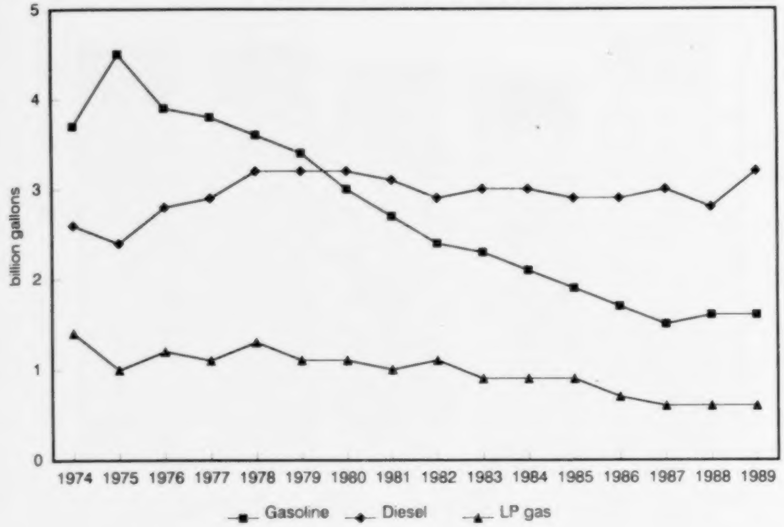
Source: See Table 48.

Figure 33.--Land in farms in the United States, by farm size, 1900-1987.



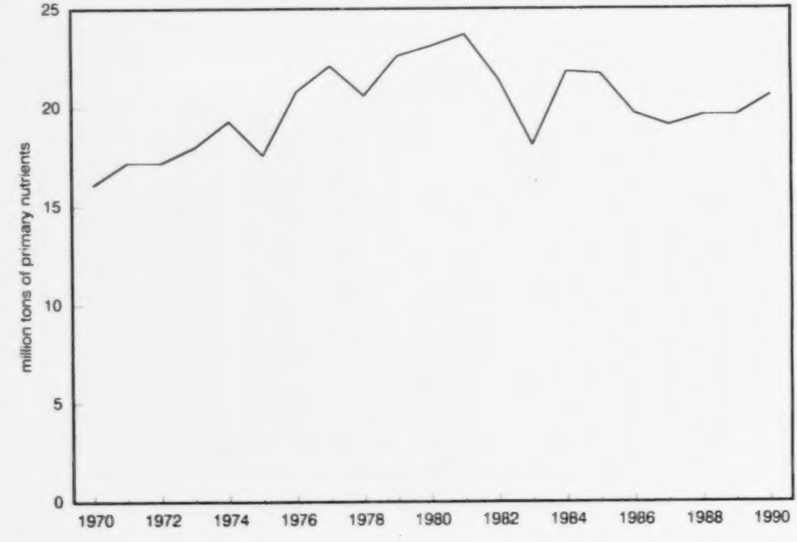
Source: See Table 48.

Figure 34.--Farm fuel use, 1974-1989.



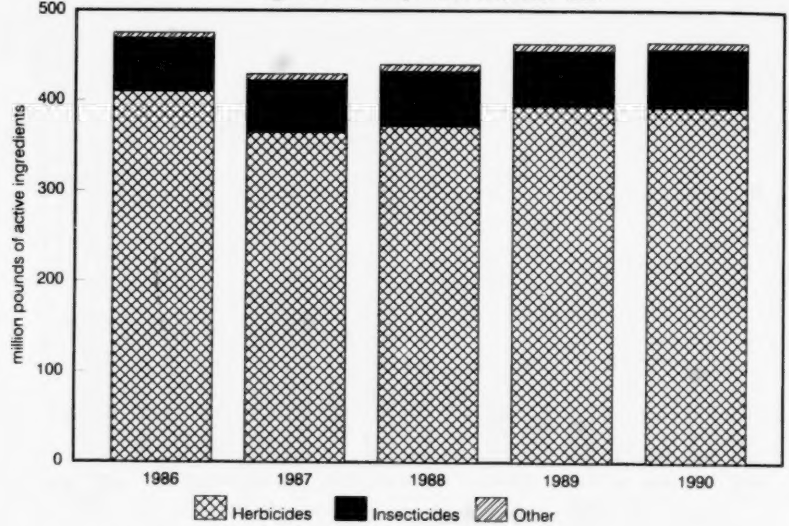
Source: See Table 53.

Figure 35.--Farm fertilizer use, 1970-1990.



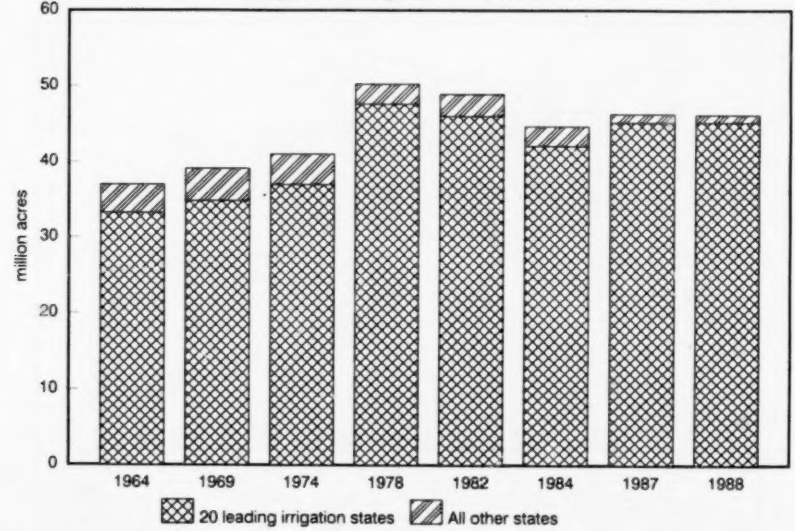
Source: See Table 54.

Figure 36.-- Farm pesticide use, 1986-1990.



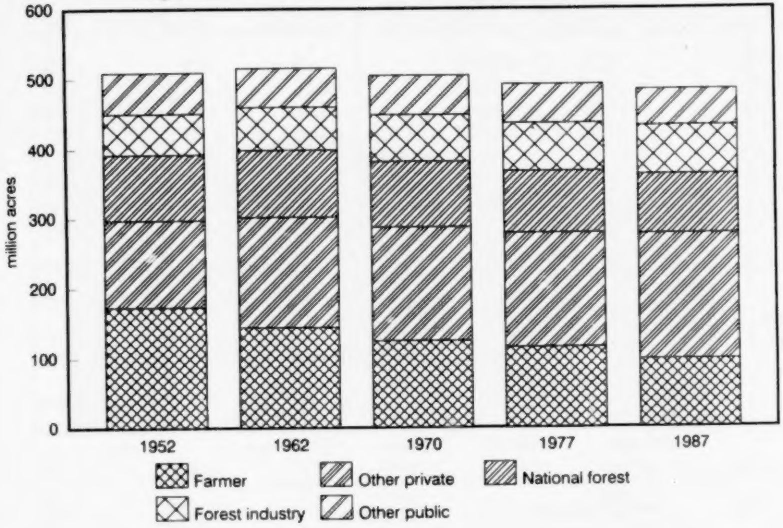
Source: See Table 55.

Figure 37.--Irrigated farmland, 1964-1988.



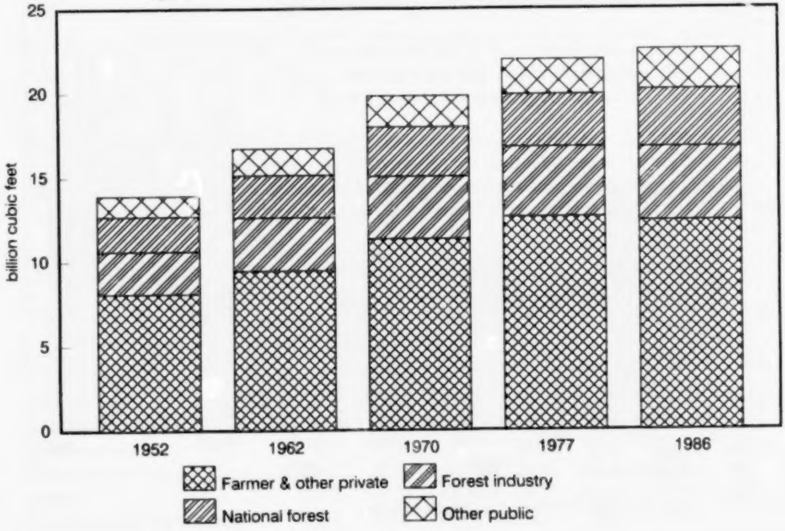
Source: See Table 56.

Figure 38.--Timberland in the United States, by ownership, 1952-1987.



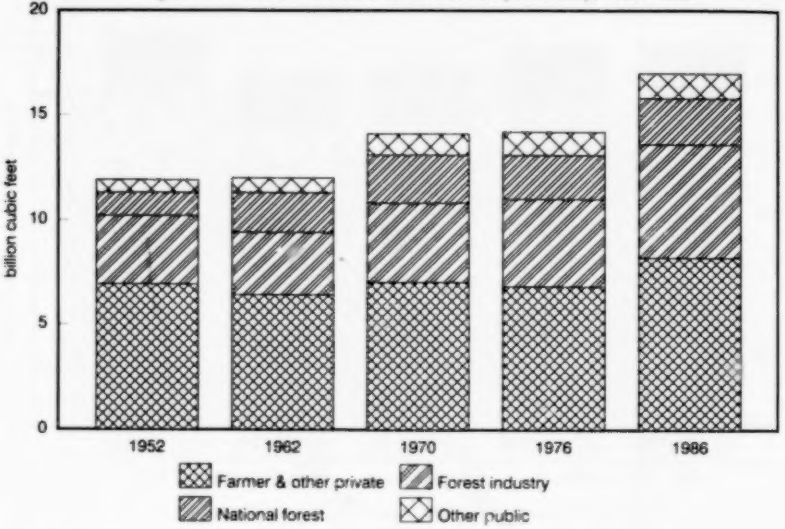
Source: See Table 58.

Figure 39.--Annual growth of timber stocks, by ownership, 1952-1986.



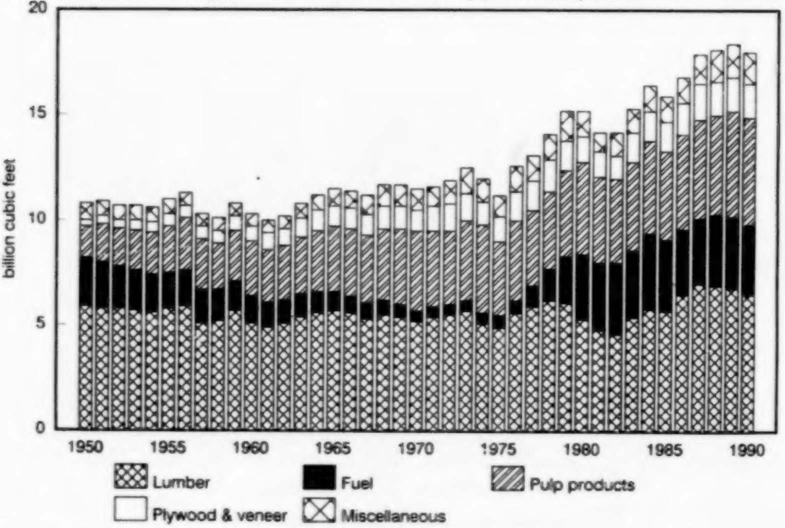
Source: See Table 59.

Figure 40.--Annual removal of timber stocks, by ownership, 1952-1986.



Source: See Table 59.

Figure 41.--Roundwood harvest, by product, 1950-1990.



Source: See Table 62.

Table 42.--Ownership of land in the United States, 1955-1987.

	Federal		Nonfederal		Total
Year	(million acres)	(percent)	(million acres)	(percent)	(million acres)
1955	408	21.4	1,496	78.6	1,904
1960	772	33.9	1,502	66.1	2,273
1965	766	33.5	1,506	66.5	2,271
1970	761	33.5	1,510	66.5	2,271
1975	760	33.5	1,511	66.5	2,271
1980	720	31.7	1,552	68.3	2,271
1985	727	32.0	1,545	68.0	2,271
1987	724	31.9	1,547	68.1	2,271

Source: U.S. Department of Commerce, Bureau of the Census. Statistical Abstract of the United States, annual. Washington, D.C.

Table 43.--Major uses of land in the United States, 1900-1987.

(million acres)

Year	Cropland	Grazing land	Forest land	Special use	Other land	Total
1900	319	832	719	na	400	1,904
1910	347	814	562	na	424	1,904
1920	402	750	567	86	330	1,904
1930	413	708	607	na	416	1,904
1940	399	723	602	99	327	1,904
1959	359	633	728	146	306	2,271
1969	333	604	723	306	293	2,264
1974	361	598	718	182	301	2,264
1978	369	587	703	158	345	2,264
1982	383	597	655	270	274	2,265
1987	464	591	648	279	282	2,265

Source: Daugherty, A.B. 1991. Major Uses of Land in the United States: 1987. U.S. Department of Agriculture, Economic Research Service. Agricultural Economic Report (AER) 535, and earlier reports in this series. Washington, D.C.

Notes: The total land area of the United States increased in 1959 with the addition of Alaska and Hawaii as states. Other changes in total land area result from refinements in measuring techniques. Within category changes result from gains and losses from bases. The estimates are not strictly comparable to data in Table 42.

Table 44.--Special uses of land in the United States, 1949-1987.

(million acres)

Land use	1949	1959	1969	1974	1978	1982	1987
Transportation	22.9	25.2	26.0	26.3	26.6	26.7	25.7
Parks and wilderness	18.8	29.7	49.3	51.6	56.6	115.8	128.5
Wildlife areas	8.9	17.2	32.1	35.8	41.4	95.2	96.4
National defense	26.3	31.1	25.6	25.0	24.9	24.0	20.9
Urban	18.3	27.2	31.0	34.8	44.6	50.2	56.6
Farmsteads & farm roads	15.1	11.4	10.3	8.1	8.4	8.0	7.1
Total	118.4	141.8	174.3	181.6	202.5	319.9	335.2

Source: Daugherty, A.B. 1991. Major Uses of Land in the United States: 1987. U.S. Department of Agriculture, Economic Research Service. Agricultural Economic Report (AER) 535, and earlier reports in this series. Washington, D.C.

Table 45.--Wetlands in the conterminous United States, 1954-1974.

(million acres)

Wetlands type	1954	1974
Estuarine wetlands	5.59	5.22
Freshwater marshes	33.07	28.40
Freshwater shrub wetlands	11.00	10.60
Freshwater forested wetlands	55.09	49.70
Other freshwater wetlands	2.70	5.00
Total wetland acreage	107.95	98.92

Source: Frayer, W.E., T.J. Monahan, D.C. Bowden & F.A. Graybill. 1983. Status and Trends of Wetlands and Deepwater Habitats in the Conterminous United States, 1950's to 1970's, table 1, pp. 20, 21. Department of Forest and Wood Sciences, Colorado State University. Ft. Collins, CO.

Table 46.--Wetlands losses, by state, 1780's-1980's.

State	Total surface area of state (million acres)	Wetlands area (million acres)		Wetlands area lost (percent)
		1780's	1980's	
Alabama	33.030	7.568	3.784	-50%
Alaska	375.304	170.200	170.000	-0.1%
Arizona	72.902	0.931	0.600	-36%
Arkansas	33.987	9.849	2.764	-72%
California	101.564	5.000	0.454	-91%
Colorado	66.719	2.000	1.000	-50%
Connecticut	3.206	0.670	0.175	-74%
Delaware	1.316	0.480	0.223	-54%
Florida	37.478	20.325	11.038	-46%
Georgia	37.681	6.843	5.298	-23%
Hawaii	4.115	0.058	0.052	-12%
Idaho	53.470	0.877	0.386	-56%
Illinois	36.096	8.212	1.255	-85%
Indiana	23.226	5.600	0.751	-87%
Iowa	36.026	4.000	0.422	-89%
Kansas	52.649	0.841	0.435	-48%
Kentucky	25.853	1.566	0.300	-81%
Louisiana	31.055	16.195	8.784	-46%
Maine	21.258	6.460	5.199	-20%

continued

Table 46 (continued).--Wetlands losses, by state, 1780's-1980's.

State	Total surface area of state (million acres)	Wetlands area (million acres)		Wetlands area lost (percent)
		1780's	1980's	
Maryland	6.769	1.650	0.440	-73%
Massachusetts	5.284	0.818	0.588	-28%
Michigan	37.258	11.200	5.583	-50%
Minnesota	53.804	15.070	8.700	-42%
Mississippi	30.538	9.872	4.067	-59%
Missouri	44.599	4.844	0.643	-87%
Montana	94.168	1.147	0.840	-27%
Nebraska	49.425	2.911	1.906	-35%
Nevada	70.746	0.487	0.236	-52%
New Hampshire	5.955	0.220	0.200	-9%
New Jersey	5.015	1.500	0.916	-39%
New Mexico	77.866	0.720	0.482	-33%
New York	31.729	2.562	1.025	-60%
North Carolina	33.655	11.090	5.690	-49%
North Dakota	45.226	4.928	2.490	-49%
Ohio	26.382	5.000	0.483	-90%
Oklahoma	44.748	2.843	0.950	-67%
Oregon	62.068	2.262	1.394	-38%
Pennsylvania	29.013	1.127	0.499	-56%
Rhode Island	0.777	0.103	0.065	-37%
South Carolina	19.875	6.414	4.659	-27%
South Dakota	49.310	2.735	1.780	-35%
Tennessee	27.036	1.937	0.787	-59%
Texas	171.097	16.000	7.612	-52%
Utah	54.346	0.802	0.558	-30%
Vermont	6.150	0.341	0.220	-35%
Virginia	26.123	1.849	1.075	-42%
Washington	43.643	1.350	0.938	-31%
West Virginia	15.476	0.134	0.102	-24%
Wisconsin	35.939	9.800	5.331	-46%
Wyoming	62.665	2.000	1.250	-38%

Source: Dahl, T.E. 1991. Wetlands Losses in the United States 1780's to 1980's. Report to Congress. U.S. Department of the Interior, Fish and Wildlife Service. Washington, D.C.

Table 47.--Number of farms and land in farms, 1900-1987.

Year	Number (million)	Land (billion acres)
1900	5.740	0.839
1910	6.366	0.879
1920	6.454	0.956
1925	6.372	na
1930	6.295	0.990
1935	6.812	na
1940	6.102	1.065
1945	5.859	1.142
1950	5.388	1.161
1954	4.783	1.160
1959	3.708	1.123
1964	3.158	1.110
1969	2.730	1.063
1974	2.314	1.017
1978	2.258	1.015
1982	2.241	0.987
1987	2.088	0.964

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical Statistics of the United States: Colonial Times to 1970. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. Census of Agriculture for 1987, and earlier reports in this series. Washington, D.C.

Note: na=not available.

Table 48.--Number of farms and land in farms, by farm size, 1900-1987.

	Farm size							
	1-49 acres		50-499 acres		500-999 acres		1,000+ acres	
Year	Number (millions)	Land (million acres)	Number (millions)	Land (million acres)	Number (millions)	Land (million acres)	Number (millions)	Land (million acres)
1900	1.93	49	3.37	520	0.10	68	0.05	200
1910	2.25	49	3.93	570	0.13	84	0.05	167
1920	2.31	59	3.93	580	0.15	100	0.07	221
1925	2.42	57	3.75	550	0.14	97	0.06	224
1930	2.36	58	3.69	550	0.16	109	0.08	277
1935	2.69	59	3.86	540	0.17	114	0.09	310
1940	2.29	50	3.55	540	0.16	112	0.10	366
1945	2.25	47	3.32	520	0.17	119	0.11	460
1950	1.97	39	3.12	500	0.18	126	0.12	495
1954	1.70	32	2.78	460	0.19	132	0.13	531
1959	1.06	22	2.32	410	0.20	137	0.14	555
1964	0.82	17	1.98	360	0.21	145	0.15	585
1969	0.64	14	1.73	320	0.22	148	0.15	578
1974	0.51	11	1.44	273	0.21	142	0.16	590
1978	0.54	12	1.34	256	0.21	147	0.16	600
1982	0.64	13	1.24	233	0.20	141	0.16	600
1987	0.59	12	0.87	212	0.20	139	0.17	602

Source: U.S. Department of Commerce, Bureau of the Census. 1976. Historical Statistics of the United States: Colonial Times to 1970. Washington, D.C.

U.S. Department of Commerce, Bureau of the Census. Census of Agriculture for 1987, and earlier reports in this series. Washington, D.C.

Table 49.--Prime farmland, by land cover type, 1977-1987.

(million acres)

Use	1977	1982	1987
Cropland	230	233	232
Pastureland	40	39	37
Rangeland	22	20	19
Forest land	42	45	45
Minor land	11	7	7
Total	345	340	339

Source: U.S. Department of Agriculture, Soil Conservation Service & Iowa State University Statistical Laboratory. Natural Resources Inventory: 1977, 1982, and 1987. Washington, D.C.

Table 50.--Major uses of cropland, 1945-1990.

(million acres)

	Cropland used for crops						Diverted from production
Year	Harvested	Failed	Summer fallow	Idle	Cropland pasture	Total	
1945	353	10	40	na	47	454	na
1949	352	9	26	22	67	478	na
1954	339	13	28	19	66	465	na
1959	317	10	31	33	66	457	22.5
1964	292	6	37	52	57	444	55.0
1969	286	6	41	51	88	472	57.5
1974	322	8	31	21	83	465	2.7
1978	330	7	32	26	76	471	18.3
1982	347	5	31	21	65	469	11.1
1987	293	6	32	68	65	464	76.2
1990	311	6	26	na	na	na	59.9

Source: U.S. Department of Agriculture, Economic Research Service. Cropland, Water and Conservation Situation and Outlook Report, annual. Washington, D.C.

Notes: Acres of idle cropland, cropland pasture, and total cropland are estimated only for years coinciding with Census of Agriculture years. Data are for the conterminous United States. Cropland diversions occurred under federal farm programs. Data for 1990 are preliminary.

Table 51.--Cropland erosion, 1977-1987.

(average annual tons per acre)

	Sheet and rill erosion			Wind erosion		
Year	Cultivated cropland	Uncultivated cropland	Average	Cultivated cropland	Uncultivated cropland	Average
1977	5.1	3.4	4.7	6.0	1.9	5.3
1982	4.7	0.8	4.3	3.4	0.4	3.1
1987	4.1	0.9	3.8	3.6	0.7	3.3

Source: U.S. Department of Agriculture, Soil Conservation Service. National Resource Inventory: 1977, 1982, and 1987. Washington, D.C.

Notes: Data for 1977 are not strictly comparable with data for 1982 and 1987 because of different reporting categories. During the period1982 to 1987, cropland acres with excessive sheet and rill erosion decreased from 104 million acres to about 94 million acres, while wind erosion damage to cropland increased slightly from 72 million acres to 76 million acres.

Table 52.--Agricultural productivity indexes, 1950-1989.

Index (1977=100)

Year	Inputs				Output	Productivity
	Labor	Mechanical	Chemical	Total		
1950	265	72	19	106	61	58
1951	251	77	21	106	62	60
1952	237	81	23	105	66	62
1953	220	82	24	103	66	64
1954	214	82	24	102	69	65
1955	220	83	29	104	69	66
1956	212	84	27	103	62	67
1957	188	83	27	100	67	67
1958	182	83	28	98	72	74
1959	183	84	32	101	74	73
1960	177	83	32	99	76	72
1961	167	80	35	98	76	78
1964	163	80	38	98	77	76
1963	155	79	43	98	80	82
1966	146	80	46	96	79	81
1965	144	80	49	97	82	84
1966	132	83	56	99	79	83
1967	128	85	66	98	83	86
1968	124	86	69	97	85	87
1969	118	86	73	96	85	88
1970	113	85	75	96	84	87
1971	108	87	81	97	92	93
1972	110	89	86	97	91	94
1973	109	90	90	98	93	95
1974	109	92	93	98	88	90
1975	106	96	83	97	95	99
1976	100	98	96	98	97	98
1977	100	100	100	100	100	100
1978	100	104	107	102	104	101
1979	99	104	123	103	111	105
1980	99	101	123	103	104	101
1981	96	98	129	103	118	115
1982	93	92	118	99	116	117
1983	97	89	102	96	96	99
1984	92	86	120	96	112	117
1985	85	80	115	92	118	125
1986	80	77	109	89	111	134
1987	78	73	111	89	110	124
1988	75	72	111	87	102	117
1989	76	73	123	88	114	128

Source: U.S. Department of Agriculture, Economic Research Service. Economic indicators of the Farm Sector: Production and Efficiency Statistics, annual. Washington, D.C.

Table 53.--Farm fuel use, 1974-1989.

(billion gallons)

Year	Gasoline	Diesel	LP gas
1974	3.7	2.6	1.4
1975	4.5	2.4	1.0
1976	3.9	2.8	1.2
1977	3.8	2.9	1.1
1978	3.6	3.2	1.3
1979	3.4	3.2	1.1
1980	3.0	3.2	1.1
1981	2.7	3.1	1.0
1982	2.4	2.9	1.1
1983	2.3	3.0	0.9
1984	2.1	3.0	0.9
1985	1.9	2.9	0.9
1986	1.7	2.9	0.7
1987	1.5	3.0	0.6
1988	1.6	2.8	0.6
1989	1.6	3.2	0.6

Source: U.S. Department of Agriculture, Economic Research Service. Agricultural Resources: Inputs Outlook and Situation Report, periodic. Washington, D.C.

Notes: Data for 1989 are preliminary. LP gas=Liquefied petroleum gas.

Table 54.--Farm fertilizer use, 1940-1990.

(million tons of primary nutrients - nitrogen, phosphorus, and potash)

Year	Amount	Year	Amount	Year	Amount
1940	1.8	1957	6.4	1974	19.3
1941	1.9	1958	6.5	1975	17.6
1942	2.1	1959	7.4	1976	20.8
1943	2.4	1960	7.5	1977	22.1
1944	2.6	1961	7.8	1978	20.6
1945	2.7	1962	8.4	1979	22.6
1946	3.1	1963	9.5	1980	23.1
1947	3.3	1964	10.5	1981	23.7
1948	3.6	1965	11.0	1982	21.4
1949	3.9	1966	12.4	1983	18.1
1950	4.1	1967	14.0	1984	21.8
1951	4.7	1968	15.0	1985	21.7
1952	5.2	1969	15.5	1986	19.7
1953	5.6	1970	16.1	1987	19.1
1954	5.9	1971	17.2	1988	19.6
1955	6.1	1972	17.2	1989	19.6
1956	6.1	1973	18.0	1990	20.6

Source: U.S. Department of Agriculture, Economic Research Service. Agricultural Resources: Inputs Outlook and Situation Report, periodic. Washington, D.C.

Table 55.--Farm pesticide use, 1964-1990.

(million pounds of active ingredients)

Year	Herbicides	Insecticides	Other	Total
1964	76	143	72	291
1966	112	138	79	328
1971	207	127	130	464
1976	374	130	146	650
1982	451	71	30	552
1986	410	59	6	475
1987	365	57	7	429
1988	372	60	8	440
1989	394	61	8	463
1990	393	64	8	465

Source: U.S. Department of Agriculture, Economic Research Service. Agricultural Resources: Inputs Outlook and Situation Report, periodic. Washington, D.C.

Notes: For the years 1964, 1966, 1972, and 1976, estimates of pesticide use are for total use on all crops in the United States. The 1982 estimates are for major field and forage crops only and represent 33 major producing states, excluding California. The 1986-1990 estimates are for major U.S. field crops. Data for 1990 are projections.

Table 56.--Irrigated farmland, 1900-1988.

(million acres)

Year	Leading irrigation states	All other states	Total
1900	7.5	0.3	7.8
1910	11.3	0.4	11.7
1920	13.9	0.6	14.5
1930	14.1	0.6	14.7
1940	17.2	0.7	18.0
1950	24.3	1.5	25.8
1959	30.7	2.4	33.2
1964	33.2	3.8	37.1
1969	34.8	4.3	39.1
1974	37.0	4.0	41.0
1978	47.8	2.6	50.4
1982	46.1	2.9	49.0
1984	42.1	2.6	44.7
1987	45.2	1.1	46.3
1988	45.2	1.0	46.2

Source: U.S. Department of Commerce, Bureau of the Census. Census of Agriculture and Other Special Ranch and Irrigation Surveys. Washington, D.C.

Notes: Leading irrigation states for 1900-1974 are the 17 Western states: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. Leading states for 1978 and 1982 are the 17 Western states plus Florida, Georgia, and Louisiana. Leading states for 1984, 1987, and 1988 are the 17 Western states plus Arkansas, Georgia, and Louisiana. All other states are conterminous states.

Table 57.--Condition of nonfederal rangeland, 1963-1987, and Bureau of Land Management rangeland, 1936-1990.

(percentage of total acreage)

Rangeland condition	Nonfederal				Bureau of Land Management				
	1963	1977	1982	1987	1936	1966	1975	1986	1990
Excellent	5	12	4	3	2	2	2	4	3
Good	15	28	30	30	14	17	15	30	30
Fair	40	42	45	47	48	52	50	41	36
Poor	40	18	16	14	36	30	33	18	16
Other	na	na	5	6	na	na	na	na	14

Source: U.S. Department of Agriculture, Soil Conservation Service. National Resources Inventory: 1977, 1982, and 1987; and earlier surveys. Washington, D.C.

U.S. Department of the Interior, Bureau of Land Management. Public Land Statistics, annual. Washington, D.C.

Notes: BLM=Bureau of Land Management. na=not available. Data are not strictly comparable because of different survey methods.

Table 58.--Timberland in the United States, by ownership, 1952-1987.

(million acres)

Year	Farmer	Other private	Forest industry	National forests	Other public	Total
1952	172.8	124.3	59.0	94.7	58.1	508.9
1962	143.6	157.6	61.4	96.8	55.6	515.1
1970	124.4	161.9	67.6	94.6	55.6	504.1
1977	114.5	163.5	68.9	88.7	55.5	491.1
1987	97.0	179.4	70.6	85.2	51.1	483.3

Source: U.S. Department of Agriculture, Forest Service, 1989. Forest Statistics of the United States, 1987. Resource Bulletin PNW-RB-168. Washington, D.C.

Table 59.--Annual growth and removal of timber stocks, by ownership, 1952-1986.

(billion cubic feet)

	Farmer and other private		Forest industry		National forest		Other public forests	
Year	Growth	Removal	Growth	Removal	Growth	Removal	Growth	Removal
1952	8.1	6.9	2.6	3.3	2.1	1.1	1.2	0.6
1962	9.5	6.4	3.2	3.0	2.5	1.9	1.6	0.7
1970	11.3	7.0	3.7	3.8	2.9	2.3	1.9	1.0
1976	12.6	6.8	4.2	4.2	3.1	2.1	2.0	1.1
1986	12.4	8.2	4.4	5.4	3.4	2.2	2.4	1.2

Source: U.S. Department of Agriculture, Forest Service, 1989. Forest Statistics of the United States, 1987. Resource Bulletin PNW-RB-168. Washington, D.C.

Table 60.--Forest fire damage and reforestation, 1930-1990.

(million acres)

Year	Forest fire damage	Reforestation
1930	52.3	0.14
1940	25.9	0.52
1950	15.5	0.50
1951	10.8	0.45
1952	14.2	0.52
1953	10.0	0.71
1954	8.8	0.81
1955	8.1	0.78
1956	6.6	0.89
1957	3.4	1.14
1958	3.3	1.53
1959	4.2	2.12
1960	4.5	2.14
1961	3.0	1.76
1962	4.1	1.37
1963	7.1	1.33
1964	4.2	1.31
1965	2.7	1.29
1966	4.6	1.28
1967	4.7	1.37
1968	4.2	1.44
1969	6.7	1.43
1970	3.3	1.60
1971	4.3	1.69
1972	2.6	1.68
1973	1.9	1.75
1974	2.9	1.60
1975	1.8	1.93
1976	5.1	1.89
1977	3.2	1.98
1978	3.9	2.09
1979	3.0	2.06
1980	5.3	2.27
1981	4.8	1.93
1982	2.4	2.37
1983	5.1	2.45
1984	3.0	2.55
1985	5.2	2.70
1986	3.2	2.75
1987	5.0	3.03
1988	5.7	3.39
1989	3.5	3.02
1990	4.6	na

Source: U.S. Department of Agriculture, Forest Service. Wildfire Statistics, annual. Washington, D.C.

U.S. Department of Agriculture, Forest Service. U.S. Forest Planting Report, annual. Washington, D.C.

Notes: Reforestation refers to acres planted in seedlings and direct seeded. Data for 1990 are preliminary. na=not available.

Table 61.--Forest land damaged by insects, 1968-1990.

(million acres)

Year	Eastern spruce budworm	Western spruce budworm	Gypsy moth	Mountain pine beetle	Southern pine beetle
1968	1.3	5.3	0.1	na	na
1969	1.2	4.6	0.3	na	na
1970	2.0	4.0	1.0	na	na
1971	1.6	4.8	1.9	na	na
1972	2.8	5.5	1.4	na	na
1973	4.2	4.4	1.8	na	na
1974	10.8	5.5	0.8	na	na
1975	9.2	5.3	0.5	na	na
1976	9.1	5.8	0.9	na	na
1977	10.3	6.5	1.6	na	na
1978	7.7	5.2	1.3	4.0	na
1979	6.6	5.0	0.6	4.4	15.0
1980	6.6	4.0	5.0	4.7	12.1
1981	4.5	5.5	12.9	4.7	0.9
1982	4.2	8.7	8.2	4.2	7.3
1983	6.5	11.0	2.4	3.6	11.4
1984	6.1	10.6	1.0	3.3	na
1985	5.2	12.8	1.7	3.3	15.5
1986	1.0	13.2	2.4	3.5	26.4
1987	0.8	8.0	1.3	2.4	13.8
1988	0.3	6.1	0.7	2.2	7.9
1989	0.1	3.1	3.0	1.6	5.3
1990	na	na	7.3	na	na

Source: U.S. Department of Agriculture, Forest Service, Forest Pest Management. 1985. Insect and Disease Conditions in the United States, 1979-1983. Washington, D.C.

U.S. Department of Agriculture, Forest Service, Forest Pest Management. Forest Insect and Disease Conditions in the United States, annual (after 1984). Washington, D.C.

Note: na=not available.

Table 62.--Roundwood harvest, by product, 1950-1990.

(billion cubic feet)

Year	Lumber	Plywood & veneer	Pulp products	Fuel	Miscel-laneous	Total
1950	5.9	0.3	1.5	2.3	0.8	10.8
1951	5.8	0.4	1.8	2.2	0.7	11.0
1952	5.8	0.4	1.8	2.0	0.7	10.8
1953	5.7	0.5	1.9	1.9	0.7	10.7
1954	5.6	0.5	2.0	1.8	0.7	10.6
1955	5.8	0.6	2.2	1.7	0.7	11.0
1956	5.9	0.6	2.5	1.7	0.6	11.3
1957	5.1	0.6	2.4	1.6	0.6	10.2
1958	5.2	0.6	2.2	1.5	0.6	10.0
1959	5.7	0.7	2.4	1.4	0.6	10.8
1960	5.1	0.7	2.6	1.3	0.6	10.2
1961	4.9	0.8	2.5	1.2	0.6	10.0
1962	5.1	0.8	2.6	1.1	0.6	10.2
1963	5.4	0.9	2.7	1.1	0.7	10.6
1964	5.6	1.0	2.9	1.0	0.7	11.2
1965	5.7	1.0	3.1	0.9	0.8	11.5
1966	5.6	1.0	3.2	0.8	0.8	11.5
1967	5.3	1.0	3.2	0.8	0.9	11.2
1968	5.5	1.1	3.4	0.7	1.0	11.8
1969	5.4	1.1	3.6	0.6	1.0	11.6
1970	5.2	1.0	3.8	0.5	1.0	11.6
1971	5.4	1.2	3.6	0.5	0.9	11.5
1972	5.5	1.3	3.5	0.5	1.1	11.9
1973	5.7	1.3	3.8	0.5	1.2	12.4
1974	5.1	1.1	4.2	0.5	1.1	12.1
1975	4.9	1.2	3.5	0.6	1.0	11.1
1976	5.6	1.4	3.8	0.6	1.2	12.5
1977	5.9	1.4	3.6	1.0	1.2	13.2
1978	6.2	1.5	3.7	1.5	1.2	14.1
1979	6.1	1.4	4.1	2.2	1.4	15.2
1980	5.3	1.2	4.4	3.1	1.2	15.2
1981	4.8	1.2	4.1	3.2	0.9	14.3
1982	4.6	1.1	4.0	3.4	1.1	14.3
1983	5.4	1.4	4.2	3.2	1.1	15.3
1984	5.8	1.4	4.4	3.6	1.2	16.3
1985	5.7	1.4	4.2	3.4	1.2	16.0
1986	6.5	1.5	4.5	3.1	1.2	17.0
1987	7.0	1.7	4.7	3.1	1.4	17.8
1988	6.9	1.6	4.7	3.4	1.5	18.2
1989	6.8	1.6	5.0	3.4	1.6	18.3
1990	6.5	1.6	5.1	3.3	1.5	18.0

Source: U.S. Department of Agriculture, Forest Service. 1991. U.S. Timber Production, Trade, Consumption, and Price Statistics, 1960-1988, table 4, p. 13, and unpublished data. Washington, D.C.

Notes: Miscellaneous=log and pulp chip exports and other products not specified. Data for 1988-1990 are preliminary. Totals may not agree with detail because of rounding.

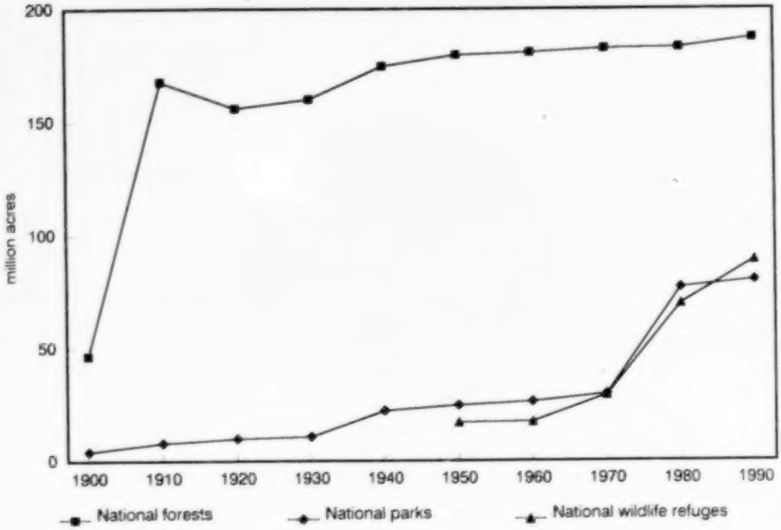
Protected Lands, Cultural and Living Resources

Protected areas often provide valuable habitat for plant and animal populations. Federal lands, such as national forests, parks, and wildlife refuges, are managed according to the mission of the agency and the designated use of the individual areas. These lands provide varying uses that range from grazing, mining, and logging to wilderness protection. The major increase in the amount of wilderness area represents a redesignation of existing federal lands to wilderness status.

Highlights include the following trends:

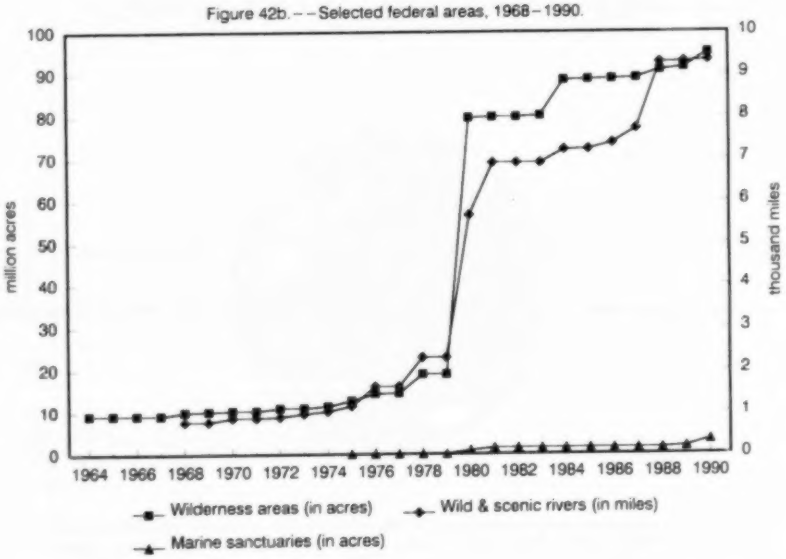
- Approximately 22 percent of the National Forest System lands, 13 percent of the Bureau of Land Management lands, and all of the National Park Service and National Wildlife Refuge lands are considered protected.
- Additions to federal protected lands in the past decade have included wilderness areas, wild and scenic rivers, and marine sanctuaries.
- Many plant and animal species have been added in the last ten years to the federal registry of threatened and endangered species.
- Most duck populations have decreased while goose populations have increased since the early 1970s; however, the dynamics of natural populations are influenced by many factors.
- Bald eagle and whooping crane populations, both endangered species, have increased since the early 1970s.

Figure 42a.--Selected federal lands, 1900-1990.



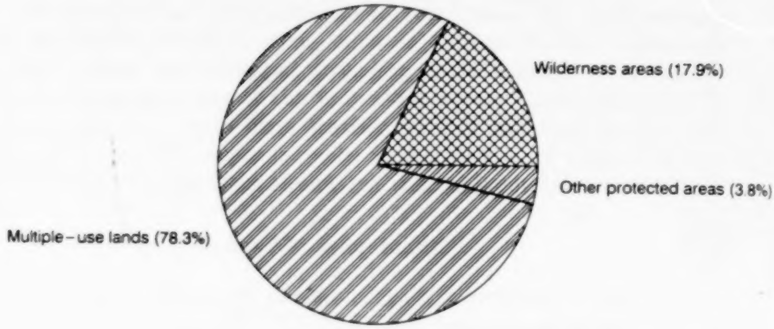
Source: See Tables 63, 64, and 65.

Figure 42b.--Selected federal areas, 1968-1990.



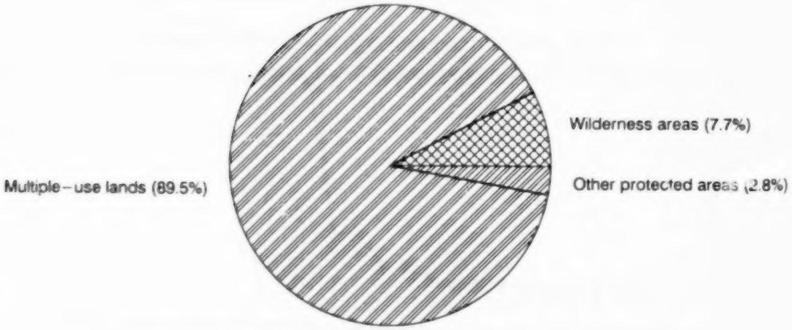
Source: See Tables 66, 67, and 68.

Figure 43a.--Special uses of Forest Service lands, 1990.



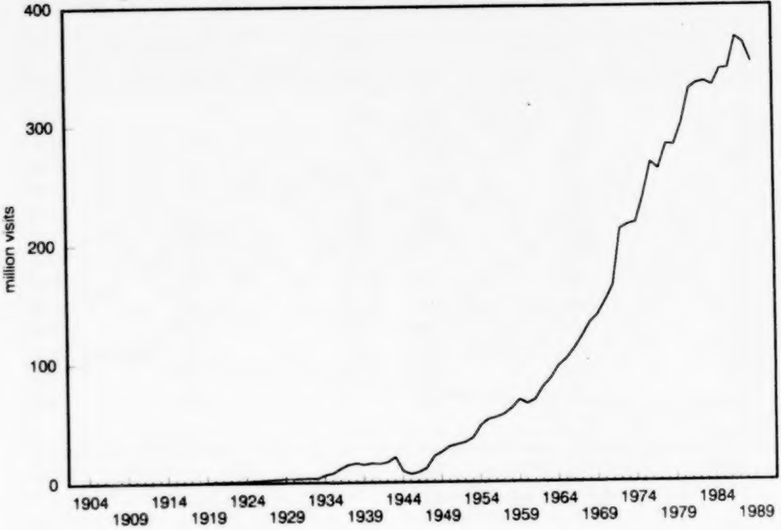
Source: See Table 69.

Figure 43b.--Special uses of Bureau of Land Management lands, 1990.



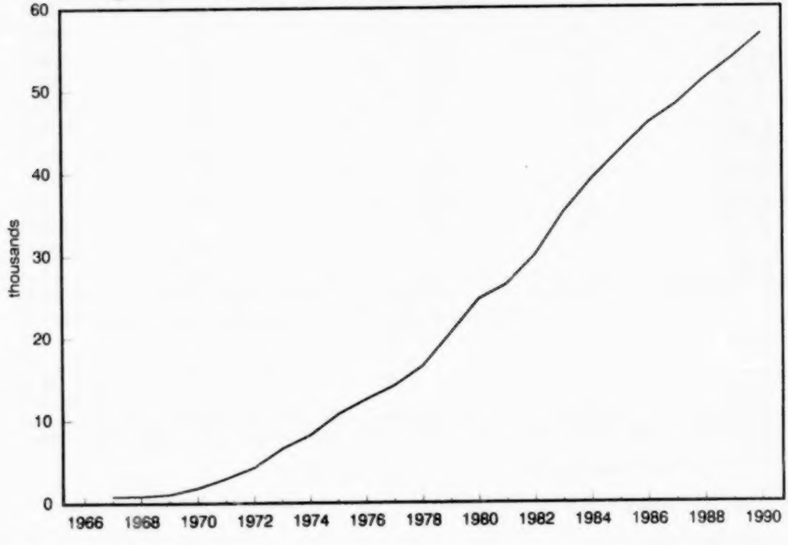
Source: See Table 69.

Figure 44.--Visits to areas administered by the National Park Service, 1904-1989.



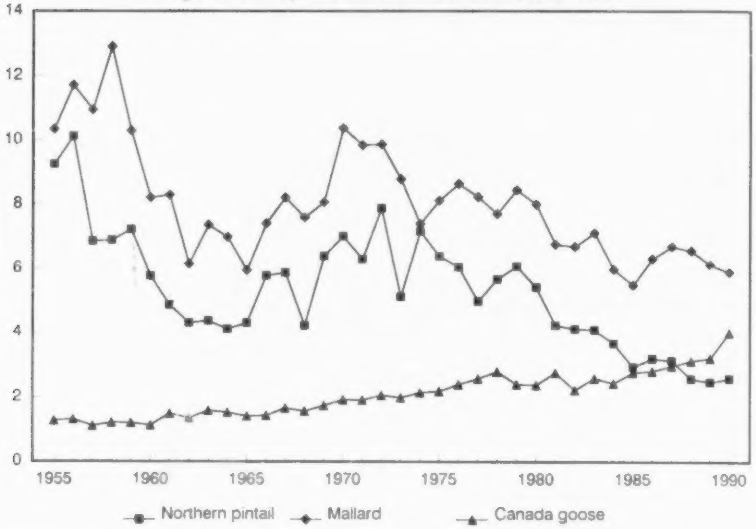
Source: See Table 70.

Figure 45.--Properties listed on the National Register of Historic Places, 1967-1990.



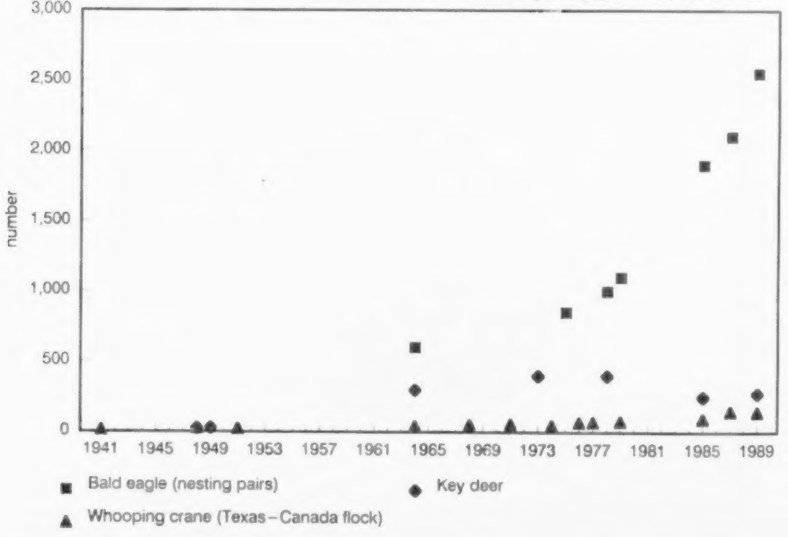
Source: See Table 71.

Figure 46.--Populations of selected waterfowl, 1955-1990.



Source: See Table 74.

Figure 47.--Estimates for selected threatened and endangered populations, 1941-1989.



Source: See Table 76.

Table 63.--National Park System, 1872-1990.

Year	Number of units	Land (million acres)
1872	1	2.2
1880	5	2.2
1890	12	3.8
1900	17	4.1
1910	45	7.9
1920	62	9.9
1930	98	10.8
1940	161	22.3
1950	182	24.6
1960	187	26.2
1970	282	29.6
1980	333	77.0
1990	358	80.1

Source: U.S. Department of the Interior, National Park Service. Areas Aadministered by the National Park Service: Information Tables, annual. Washington, D.C.

Table 64.--National Wildlife Refuge System, 1920-1990.

Year	Number of units	Land (million acres)
1920	36	na
1940	174	na
1946	242	17.5
1950	248	17.1
1955	276	17.3
1960	275	17.3
1965	299	28.4
1970	332	29.2
1975	378	32.3
1978	390	32.6
1980	419	69.9
1985	432	88.3
1990	477	89.1

Source: U.S. Department of the Interior, Fish and Wildlife Service. Lands Under the Control of the Fish and Wildlife Service, summary. Washington, D.C.

Note: na=not available.

Table 65.--National Forest System, 1891-1990.

Year	Number of forests	Land (million acres)	Year	Number of forests	Land (million acres)
1891	1	1.24	1945	155	177.64
1895	17	17.93	1950	151	179.69
1900	38	46.52	1955	149	180.30
1905	83	75.35	1960	151	180.84
1910	149	168.03	1965	154	182.14
1915	162	162.77	1970	154	182.57
1920	152	156.03	1975	155	183.28
1925	159	158.40	1980	155	183.06
1930	149	160.09	1985	156	186.31
1935	142	163.31	1990	156	187.08
1940	160	174.77			

Source: U.S. Department of Agriculture, Forest Service. Land Areas of the National Forest System, as of September 30, 1990. Washington, D.C.

Table 66.--National Wilderness Preservation System, 1964-1990.

Year	Land (million acres)	Year	Land (million acres)	Year	Land (million acres)
1964	9.24	1973	11.03	1982	79.88
1965	9.24	1974	11.38	1983	80.21
1966	9.24	1975	12.72	1984	88.55
1967	9.24	1976	14.45	1985	88.70
1968	10.03	1977	14.49	1986	88.80
1969	10.19	1978	19.00	1987	88.99
1970	10.40	1979	19.00	1988	90.81
1971	10.40	1980	79.71	1989	91.46
1972	11.03	1981	79.84	1990	94.99

Source: U.S. Department of Agriculture, Forest Service. National Wilderness Preservation System, annual fact sheet. Washington, D.C.

Table 67.--National Wild and Scenic River System, 1968-1990.

Year	River miles	Year	River miles	Year	River miles
1968	773	1976	1,610	1984	7,217
1969	773	1977	1,610	1985	7,224
1970	868	1978	2,299	1986	7,363
1971	868	1979	2,299	1987	7,709
1972	895	1980	5,662	1988	9,264
1973	961	1981	6,908	1989	9,281
1974	1,018	1982	6,908	1990	9,318
1975	1,145	1983	6,908		

Source: U.S. Department of the Interior, National Park Service. River Mileage Classifications for Components of the National Wild and Scenic River System, unpublished data. Washington, D.C.

Table 68.--National Estuarine Research Reserves and National Marine Sanctuaries, 1975-1990.

	Estuarine Research Reserves		Marine Sanctuaries	
Year	Number	Area (acres)	Number	Area (acres)
1975	1	4,700	2	64,640
1976	3	14,205	2	64,640
1978	4	22,605	2	64,640
1979	5	216,383	2	64,640
1980	9	223,426	3	865,920
1981	11	229,652	6	1,486,720
1982	14	240,571	6	1,486,720
1984	15	242,121	6	1,486,720
1986	16	245,149	7	1,487,360
1988	17	247,348	7	1,487,360
1989	18	253,477	8	1,741,440
1990	18	259,945	9	3,337,600

Source: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Marine and Estuarine Management Division, unpublished data. Washington, D.C.

Table 69.–Distribution of protected areas within selected federal lands, 1990.

National Forest System	Area (acres)	Percentage of total National Forest land area
National Wilderness Areas	33,609,661	17.965
National Primitive Areas	173,762	0.093
National Scenic Research Areas	6,416	0.003
National Wild and Scenic Rivers	331,212	0.177
National Recreation Areas	2,024,559	1.082
National Game Refuges	1,218,953	0.652
National Monuments	3,329,920	1.780
Research and Experimental Areas	64,933	0.035
Total protected area	40,694,483	21.752
Total NFS land	187,083,200	

Bureau of Land Management	Area (acres)	Percentage of total BLM land area
National Wilderness Areas	20,688,827	7.675
Areas of Critical Environmental Concern	6,623,313	2.457
Research Natural Areas	203,170	0.075
Outstanding Natural Areas	222,591	0.083
National Natural Landmarks	632,681	0.235
Total protected area	28,370,582	10.525
Total BLM land	269,553,883	

Source: U.S. Department of Agriculture, Forest Service. Land Areas of the National Forest System, as of September 30, 1990. Washington, D.C.

U.S. Department of the Interior, Bureau of Land Management. Public Land Statistics, 1989. Washington, D.C.

U.S. Department of Agriculture, Forest Service. National Wilderness Preservation System, annual fact sheet. Washington, D.C.

Note: BLM=Bureau of Land Management. BLM also administers 1,982 miles of National Wild and Scenic Rivers. National Wilderness Area data updated by Sources.

Table 70.--Visits to areas administered by the National Park Service, 1905-1989.

(millions)

Year	Visits	Year	Visits	Year	Visits
1905	0.14	1935	7.88	1965	102.71
1910	0.20	1940	16.33	1970	150.84
1915	0.34	1945	6.83	1975	238.85
1920	1.06	1950	29.86	1980	300.32
1925	2.05	1955	52.27	1985	346.19
1930	3.25	1960	65.46	1989	351.90

Source: U.S. Department of the Interior, National Park Service, Statistical Office. National Park Statistical Abstract, annual. Denver, CO.

Table 71.--National Register of Historic Places, 1967-1990.

Year	Properties listed	Properties removed	Year	Properties listed	Properties removed
1967	873	2	1979	20,589	366
1968	903	3	1980	24,680	403
1969	1,106	4	1981	26,499	406
1970	1,888	19	1982	29,999	420
1971	3,026	51	1983	35,112	434
1972	4,376	93	1984	39,121	440
1973	6,646	144	1985	42,538	445
1974	8,247	188	1986	45,936	452
1975	10,805	231	1987	48,254	525
1976	12,561	265	1988	51,286	574
1977	14,203	290	1989	53,838	635
1978	16,575	338	1990	56,688	651

Source: U.S. Department of the Interior, National Park Service. The National Register of Historic Places, unpublished data. Washington, D.C.

Table 72.--Trends in selected permanent resident bird populations, 1966-1989.

(percent change per year)

Common name	1966-1978	1980-1989
Northern bobwhite	-3.6	-2.5
Great horned owl	0.8	0.3
Downy woodpecker	-0.2	-0.6
Hairy woodpecker	1.8	0.3
Pileated woodpecker	1.2	1.4
Black-capped chickadee	1.8	1.5
Carolina chickadee	0.0	-0.8
Tufted titmouse	-2.0	1.9
Brown-headed nuthatch	-1.9	-1.3
Carolina wren	1.2	3.5
Northern mockingbird	-1.7	1.0
Northern cardinal	-0.9	0.4
House sparrow	-1.4	-2.7

Source: Robbins, C.S., J.R. Sauer, R.S. Greenberg & S. Droege. 1989. Population Declines in North American Birds that Migrate to the Neotropics. Proc. Natl. Acad. Sci. 86, pp. 7658-7662.

Table 73.--Trends in selected neotropical migrant bird populations, 1966-1989.

(percent change per year)

Common name	1966-1978	1980-1989
Yellow-billed cuckoo	1.8	-7.0
Whip-poor-will	0.6	-2.3
Eastern wood pewee	-2.1	-1.4
Least flycatcher	-1.6	-0.1
Veery	1.6	-2.3
Wood thrush	1.3	-3.9
White-eyed vireo	0.3	-2.1
Red-eyed vireo	2.8	1.0
Tennessee warbler	18.6	-4.2
Blackburnian warbler	1.3	-0.8
American redstart	1.3	-1.0
Prothonotary warbler	4.4	-1.0
Ovenbird	1.0	-1.2
Common yellowthroat	0.2	-0.6
Yellow-breasted chat	-4.5	-2.0
Scarlet tanager	2.6	0.6
Rose-breasted grosbeak	6.1	-1.2
Indigo bunting	0.4	-1.2

Source: Robbins, C.S., J.R. Sauer, R.S. Greenberg & S. Droege. 1989. Population Declines in North American Birds that Migrate to the Neotropics. Proc. Natl. Acad. Sci. 86, pp. 7658-7662.

Table 74.--Population estimates and indices for selected waterfowl, 1955-1990.

(thousands)

	Population estimate				Population indices	
Year	Northern pintail	Mallard	Canvasback	Redhead	Canada goose	Tundra swan
1955	9,251	10,345	595	733	1,278	90
1956	10,124	11,711	692	928	1,319	39
1957	6,856	10,946	600	684	1,108	40
1958	6,889	12,904	713	524	1,215	28
1959	7,228	10,292	481	641	1,205	28
1960	5,769	8,206	575	542	1,136	41
1961	4,860	8,290	396	437	1,493	63
1962	4,299	6,144	385	664	1,360	39
1963	4,361	7,360	523	396	1,590	61
1964	4,111	6,974	658	560	1,524	62
1965	4,301	5,948	505	568	1,411	54
1966	5,777	7,401	683	747	1,434	58
1967	5,870	8,205	556	846	1,655	72
1968	4,225	7,586	557	502	1,571	46
1969	6,390	8,065	530	759	1,743	62
1970	7,004	10,379	601	634	1,925	55
1971	6,291	9,843	441	693	1,921	58
1972	7,875	9,867	429	489	2,065	63
1973	5,114	8,781	696	754	1,989	57
1974	7,165	7,392	493	613	2,140	64
1975	6,387	8,109	706	974	2,187	67
1976	6,045	8,637	686	946	2,406	79
1977	4,971	8,226	702	688	2,575	76
1978	5,664	7,695	423	833	2,793	70
1979	6,070	8,444	606	774	2,407	79
1980	5,420	8,003	688	1,145	2,383	60
1981	4,227	6,757	594	825	2,764	93
1982	4,112	6,684	543	674	2,225	73
1983	4,086	7,107	528	886	2,592	86
1984	3,664	5,974	569	849	2,435	81
1985	2,935	5,475	411	701	2,763	94
1986	3,201	6,303	442	956	2,816	91
1987	3,137	6,691	478	767	2,969	94
1988	2,577	6,550	435	846	3,130	77
1989	2,471	6,119	488	628	3,212	91
1990	2,590	5,900	593	606	4,001	90

Source: U.S. Department of the Interior, Fish and Wildlife Service, Office of Migratory Bird Management in conjunction with the Canadian Wildlife Service. 1989 Status of Waterfowl and Fall Flight Forecast. Washington, D.C.

Notes: Estimates for northern pintail, mallard, and canvasback are for breeding populations. Indices for Canada goose include cackling goose and are based on fall and winter surveys. Indices for tundra swan are for the eastern population from winter surveys.

Table 75.--Threatened and endangered U.S. wildlife and plants, 1980-1990.

(number, cumulative)

	Threatened				Endangered			
Group	1980	1985	1987	1990	1980	1985	1987	1990
Mammals	3	4	7	8	32	20	50	53
Birds	3	3	10	11	66	59	76	74
Reptiles	10	8	18	17	13	8	15	16
Amphibians	3	3	4	5	5	5	5	6
Fishes	12	14	30	33	34	30	47	54
Snails	5	5	5	6	2	3	3	3
Crustaceans	0	1	1	2	1	3	7	8
Insects	6	4	7	9	7	8	10	11
Arachnids	0	0	0	0	0	0	3	3
Clams	0	0	0	2	23	22	30	37
Plants	7	10	44	60	51	67	158	180
Total	49	52	126	153	234	225	404	445

Source: U.S. Department of the Interior, Fish and Wildlife Service, Division of Endangered Species and Habitat Conservation, unpublished data. Washington, D.C.

Table 76.--Estimates for selected threatened and endangered populations, 1941-1989.

Year	Bald eagle (minimum estimate of nesting pairs)	Whooping crane (number in Texas-Canada flock)	Key deer (number of individuals)
1941	na	16	na
1948	na	30	26
1949	na	34	30
1951	na	25	na
1964	600	42	300
1968	na	50	na
1969	na	56	na
1970	na	57	na
1971	na	59	na
1972	na	51	na
1973	na	49	400
1974	na	49	na
1975	850	57	na
1976	na	69	na
1977	na	72	na
1978	1,000	75	400
1979	1,100	76	na
1985	1,900	97	250
1987	2,100	148	na
1989	2,550	145	e

Source: U.S. Department of the Interior, Fish and Wildlife Service, Division of Endangered Species and Habitat Conservation, unpublished data. Washington, D.C.

Notes: e=250-300 individuals. na=not available.

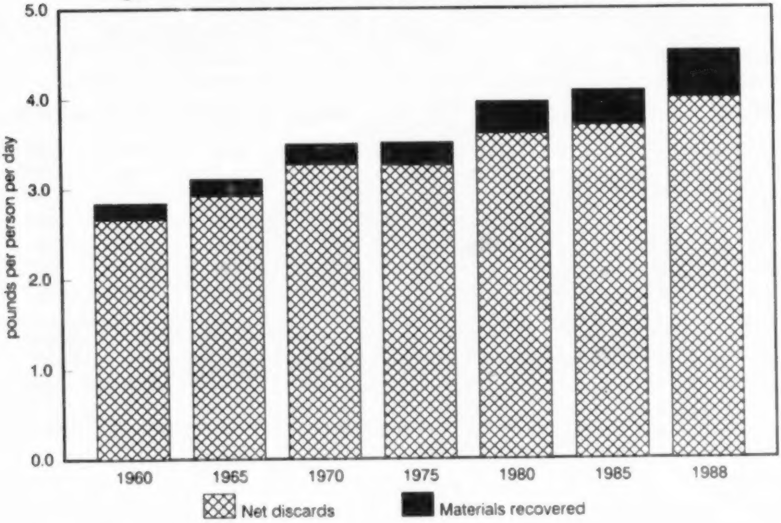
Environmental Waste and Hazards

Data on the amount and disposition of some wastes are available only for recent years and are subject to changing definitions and collection procedures. These limitations apply to the Environmental Protection Agency's Toxics Release Inventory (TRI), which includes data only for 1987 and 1988. While the TRI data show apparent reductions in releases of toxic chemicals, these may relate more to how volumes of the 322 chemicals were estimated or reported rather than to changes in waste generation practices.

Highlights include the following trends:

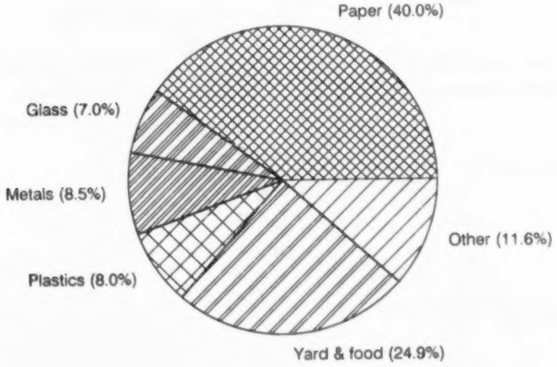
- Gross discards of municipal solid waste per capita continue to increase with an increasing proportion of materials recovered.
- Municipal solid wastes are dominated by paper and paperboard wastes, both on a weight and volume basis.

Figure 48.--Municipal solid waste disposal and recovery, per capita, 1960-1988.



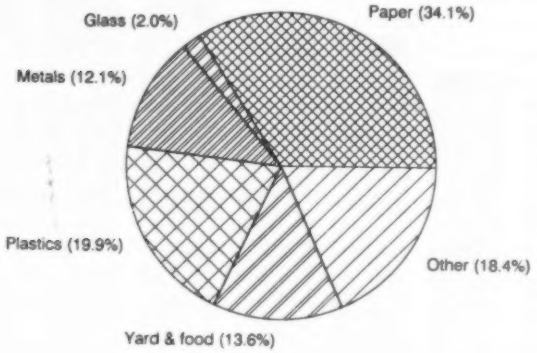
Source: See Table 77.

Figure 49a.--Materials generated in the municipal waste stream, by weight, 1988.



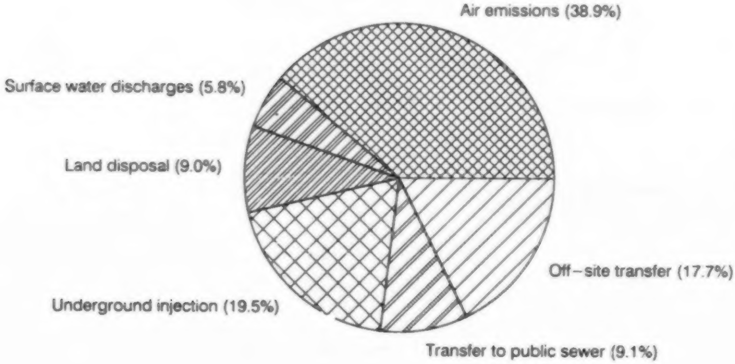
Note: Total weight = 179.6 million tons.
Source: See Table 78.

Figure 49b.--Material discards in the municipal waste stream, by volume, 1988.



Note: Total volume = 400 million cubic yards.
Source: See Source for Table 78.

Figure 50.--Environmental distribution of TRI releases and transfers, 1988.



Note: TRI = Toxics Release Inventory. Total releases and transfers = 6,241 million pounds.
Source: See Table 84.

Table 77.--Municipal solid waste generation and recovery, 1960-1988.

Year	Gross discards		Materials recovery		Percent recovery	Net discards	
	Total (million tons)	Per capita (pounds per day)	Total (million tons)	Per capita (pounds per day)	(%)	Total (million tons)	Per capita (pounds per day)
1960	87.8	2.66	5.9	0.18	6.7	81.9	2.48
1965	103.4	2.92	6.8	0.19	6.6	96.6	2.73
1970	121.9	3.27	8.6	0.23	7.1	113.3	3.04
1975	128.1	3.26	9.9	0.25	7.7	118.2	3.01
1980	149.6	3.61	14.5	0.35	9.7	135.1	3.26
1985	161.6	3.70	16.4	0.38	10.1	145.2	3.32
1988	179.6	4.00	23.5	0.52	13.1	156.0	3.48

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Characterization of Municipal Solid Waste in the United States, 1990 Update. Washington, D.C.

Notes: Totals may not agree with detail because of independent rounding.

Table 78.--Municipal solid waste generation, by waste type, 1960-1988.

(million tons)

Year	Paper	Glass	Metal	Aluminum	Plastics	Rubber & leather	Textiles	Wood	Yard & food
1960	29.9	6.7	10.1	0.4	0.4	2.0	1.7	3.0	33.5
1965	38.0	8.7	10.6	0.5	1.4	2.6	1.9	3.5	35.9
1970	44.2	12.7	13.3	0.8	3.1	3.2	2.0	4.0	37.8
1975	43.0	13.5	13.2	1.1	4.5	3.9	2.2	4.4	40.6
1980	54.7	15.0	12.7	1.8	7.8	4.3	2.6	4.9	42.9
1985	61.5	13.2	11.9	2.3	11.6	3.8	2.8	5.4	45.7
1988	71.8	12.5	12.7	2.5	14.4	4.6	3.9	6.5	47.5

Source: U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Characterization of Municipal Solid Waste in the United States, 1990 Update. Washington, D.C.

Table 79.--Accumulated volume and radioactivity of low-level nuclear waste at commercial disposal sites, 1963-1989.

Year	Volume (million m3)	Radio-activity (million curies)	Year	Volume (million m3)	Radio-activity (million curies)
1963	0.008	0.028	1977	0.514	4.987
1964	0.020	0.192	1978	0.593	5.884
1965	0.034	0.285	1979	0.676	6.373
1966	0.049	0.387	1980	0.768	6.709
1967	0.071	0.554	1981	0.852	6.986
1968	0.091	0.683	1982	0.929	7.400
1969	0.112	0.818	1983	1.007	7.906
1970	0.138	1.028	1984	1.083	8.507
1971	0.169	2.225	1985	1.160	9.256
1972	0.208	2.629	1986	1.213	9.489
1973	0.255	3.207	1987	1.265	9.759
1974	0.309	3.411	1988	1.306	10.018
1975	0.367	3.867	1989	1.352	10.885
1976	0.442	4.287			

Source: U.S. Department of Energy. 1990. Integrated Data Base for 1990: Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, table 4.10, p. 114, and table 4.11, p.115 Washington, D.C.

Note: m3=cubic meters.

Table 80.--Accumulated volume and radioactivity of high-level nuclear waste, 1980-1990.

Year	DOE/defense		Commercial	
	Volume (million m3)	Radio-activity (billion curies)	Volume (thousand m3)	Radio-activity (million curies)
1980	0.30	1.31	2.20	35.00
1981	0.31	1.58	2.20	34.20
1982	0.34	1.32	2.20	33.40
1983	0.35	1.25	2.20	32.70
1984	0.36	1.40	2.20	31.90
1985	0.36	1.47	2.20	31.20
1986	0.36	1.41	2.20	30.40
1987	0.38	1.27	2.20	29.70
1988	0.38	1.17	2.10	29.30
1989	0.38	1.08	1.90	27.90
1990	0.40	1.03	1.60	27.20

Source: U.S. Department of Energy. 1990. Integrated Data Base for 1990: Spent Fuel and Radioactive Waste Inventories, Projections, and Characteristics, table 2.1, p. 47, Washington, D.C.

Notes: DOE=U.S. Department of Energy. defense=defense-related activities. m3= cubic meters.

Table 81.--Radiation levels in air and pasteurized milk, 1960-1990.

(annual mean exposure, in picocuries per liter)

Year	Krypton-85 in air	Strontium-90 in pasteurized milk	Cesium-137 in pasteurized milk
1960	na	8.6	18.0
1961	na	8.0	11.0
1962	7.5	13.4	44.0
1963	9.0	23.5	108.0
1964	9.5	23.8	109.0
1965	10.0	17.6	58.0
1966	11.0	13.3	29.0
1967	11.5	10.2	16.0
1968	12.5	8.9	11.0
1969	13.5	7.5	9.0
1970	15.4	7.3	8.0
1971	14.8	6.8	9.0
1972	14.9	5.6	6.0
1973	16.7	4.4	5.0
1974	17.0	4.7	8.0
1975	17.5	3.9	9.0
1976	16.5	3.5	7.0
1977	17.1	3.6	6.0
1978	na	3.8	7.3
1979	21.8	3.5	4.0
1980	na	2.8	6.8
1981	na	2.8	2.5
1982	26.4	2.8	4.1
1983	38.6	2.3	1.6
1984	na	2.1	2.1
1985	na	2.0	2.7
1986	na	1.9	5.5
1987	na	1.9	6.6
1988	na	1.6	4.0
1989	na	1.4	3.2
1990	na	na	2.7

Source: U.S. Environmental Protection Agency, Office of Radiation Programs, National Air and Radiation Environmental Laboratory. Environmental Radiation Data Report EPA-520/5, quarterly issues. Montgomery, AL.

Note: na=not available.

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Table 82.--U.S. production of synthetic organic chemical products, 1967-1989.

	Year											
Product	1967	1969	1971	1973	1975	1977	1979	1981	1983	1985	1987	1989
Crude coal tar	na	na	na	na	na	593	590	464	284	na	189	156
Petroleum	na	71	81	91	78	126	121	110	110	105	101	136
Cyclic intermed.	21	29	30	36	31	19	50	45	43	46	55	66
Dyes	206	240	244	284	206	264	266	230	244	222	255	467
Organic pigm'ts	53	61	58	69	50	69	88	76	78	81	94	134
Medic'l chem.	180	200	223	234	208	241	313	245	233	225	261	349
Flavor/perfume	112	120	96	117	101	150	195	165	174	152	126	172
Plastic & resin	14	19	21	30	25	35	42	41	44	50	60	72
Rubber	264	303	323	401	279	402	395	280	293	260	382	472
Elastomers	4	5	5	6	5	6	6	5	4	4	5	6
Plasticizers	1	1	2	2	1	2	2	2	2	2	2	3
Surface ag'ts	4	4	4	4	4	5	5	5	5	5	6	8
Pesticides	1	1	1	1	2	1	1	1	1	1	1	2
Miscellaneous	60	76	80	99	86	106	121	117	114	116	123	167

Source: U.S. International Trade Commission. Synthetic Organic Chemicals, United States Production and Sales, 1988 and earlier issues in this series. Washington, D.C.

Notes: Quantities are million gallons for crude coal tar, million pounds for dyes, organic pigments, medicinal chemicals, flavor and perfume, and rubber, and billion pounds for petroleum, cyclic intermediates, plastic and resins, elasticizers, plasticizers, surface-active agents, pesticides, and miscellaneous. Petroleum=Primary products from petroleum and natural gas for chemical conversion.

Table 83.--U.S. production of selected synthetic organic chemicals, 1950-1989.

(billion pounds)

Year	Acrylo-nitrile	Benzene (all grades)	Vinyl (monomer) chlorides	Phthalates (anhydride phthalic)	PCBs
1950	na	na	0.25	0.14	na
1955	0.12	na	0.53	0.21	na
1960	0.23	na	1.04	0.34	0.04
1961	0.25	na	1.04	0.38	0.04
1962	0.36	na	1.31	0.47	0.04
1963	0.46	na	1.44	0.52	0.04
1964	0.59	na	1.82	0.60	0.05
1965	0.77	6.08	2.00	0.68	0.06
1966	0.72	7.02	2.50	0.75	0.07
1967	0.67	7.12	2.42	0.78	0.08
1968	1.02	7.50	2.97	0.84	0.08
1969	1.16	9.01	3.74	0.88	0.08
1970	1.04	8.69	4.04	0.86	0.09
1971	0.98	7.91	4.34	0.98	0.04
1972	1.11	9.20	5.09	1.15	0.04
1973	1.35	10.68	5.35	1.20	0.04
1974	1.41	10.94	5.82	1.21	0.04
1975	1.21	7.52	4.20	0.90	0.03
1976	1.52	10.47	5.68	1.04	0.03
1977	1.65	10.55	5.99	1.20	0.01
1978	1.75	10.94	6.94	1.26	0.00
1979	2.02	12.29	7.54	1.29	0.00
1980	1.83	11.64	6.47	1.05	0.00
1981	2.00	9.84	6.87	1.12	0.00
1982	2.04	7.85	6.50	0.95	0.00
1983	2.15	9.70	6.88	1.15	0.00
1984	2.22	10.00	6.08	1.18	0.00
1985	2.35	10.25	9.46	0.82	0.00
1986	2.31	9.97	8.44	0.86	0.00
1987	2.50	10.86	8.55	1.02	0.00
1988	2.61	11.63	9.06	1.00	0.00
1989	2.36	11.94	10.13	0.92	0.00

Source: U.S. International Trade Commission. Synthetic Organic Chemicals, United States Production and Sales, 1989 and earlier issues. Washington, D.C.

Notes: PCBs=Polychlorinated biphenyls. PCBs have not been produced in the United States since 1978. na=not available.

Table 84.--Environmental distribution of TRI releases and transfers, 1987-1988.

(million pounds)

Type of release or transfer	1987	1988
Air emissions	2,575.97	2,427.57
Surface water discharges	403.07	361.59
Land disposal	730.90	561.58
Underground injection	1,298.74	1,215.34
Transfer to public sewerage	614.83	570.55
Off-site transfers	1,353.93	1,104.41
Total releases & transfers	6,977.43	6,241.03

Source: U.S. Environmental Protection Agency, Office of Toxic Substances. 1990. Toxics in the Community: National and Local Perspectives. The 1988 Toxics Release Inventory National Report (EPA 560/4-90-017). Washington, D.C.

Notes: TRI=Toxics Release Inventory. The major reasons for the reported changes in TRI releases and transfers are discussed in the Source report.

APPENDIX

THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

(as Amended[1]*)*

An Act to establish a national policy for the environment, to provide for the establishment of a Council on Environmental Quality, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "National Environmental Policy Act of 1969."

Purpose

Sec. 2. The purposes of this Act are: To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

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[1] Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258, § 4(b), Sept. 13, 1982.)

TITLE I
Declaration of National Environmental Policy

Sec. 101. (a) The Congress, recognizing the profound impact of man's activity on the interrelations of all components of the natural environment, particularly the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans.

(b) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may —

(1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;

(2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;

(3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;

(4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

(c) The Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment.

Sec. 102. The Congress authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in this Act, and (2) all agencies of the Federal Government shall —

(A) Utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment;

(B) Identify and develop methods and procedures, in consultation with the Council on Environmental Quality established by title II of this Act, which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations;

(C) Include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on —

(i) The environmental impact of the proposed action,

(ii) Any adverse environmental effects which cannot be avoided should the proposal be implemented,

(iii) Alternatives to the proposed action,

(iv) The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and

(v) Any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate Federal, State, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by section 552 of title 5, United States Code, and shall accompany the proposal through the existing agency review processes;

(D) Any detailed statement required under subparagraph (c) after January 1, 1970, for any major Federal action funded under a program of grants to States shall not be deemed to be legally insufficient solely by reason of having been prepared by a State agency or official, if:

(i) the State agency or official has statewide jurisdiction and has the responsibility for such action,

(ii) the responsible Federal official furnishes guidance and participates in such preparation,

(iii) the responsible Federal official independently evaluates such statement prior to its approval and adoption, and

(iv) after January 1, 1976, the responsible Federal official provides early notification to, and solicits the views of, any other State or any Federal land management entity of any action or any alternative thereto which may have significant impacts upon such State or affected Federal land management entity and, if there is any disagreement on such impacts, prepares a written assessment of such impacts and views for incorporation into such detailed statement.

The procedures in this subparagraph shall not relieve the Federal official of his responsibilities for the scope, objectivity, and content of the entire statement or of any other responsibility under this Act; and further, this subparagraph does not affect the legal sufficiency of statements prepared by State agencies with less than statewide jurisdiction.

(E) Study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources;

(F) Recognize the worldwide and long-range character of environmental problems and, where consistent with the foreign policy of the United States, lend appropriate support to initiatives, resolutions, and programs designed to maximize international cooperation in anticipating and preventing a decline in the quality of mankind's world environment;

(G) Make available to States, counties, municipalities, institutions, and individuals, advice and information useful in restoring, maintaining, and enhancing the quality of the environment;

(H) Initiate and utilize ecological information in the planning and development of resource-oriented projects; and

(I) Assist the Council on Environmental Quality established by title II of this Act.

Sec. 103. All agencies of the Federal Government shall review their present statutory authority, administrative regulations, and current policies and procedures for the purpose of determining whether there are any deficiencies or inconsistencies therein which prohibit full compliance with the purposes and provisions of this Act and shall propose to the President not later than July 1, 1971, such measures as may be necessary to bring their authority and policies into conformity with the intent, purposes, and procedures set forth in this Act.

Sec. 104. Nothing in section 102 or 103 shall in any way affect the specific statutory obligations of any Federal agency (1) to comply with criteria or standards of environmental quality, (2) to coordinate or consult with any other Federal or State agency, or (3) to act, or refrain from acting contingent upon the recommendations or certification of any other Federal or State agency.

Sec. 105. The policies and goals set forth in this Act are supplementary to those set forth in existing authorizations of Federal agencies.

TITLE II

Council on Environmental Quality

Sec. 201. The President shall transmit to the Congress annually beginning July 1, 1970, an Environmental Quality Report (hereinafter referred to as the "report") which shall set forth (1) the status and condition of the major natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban and rural environment; (2) current and foreseeable trends in the quality, management and utilization of such environments and the effects of those trends on the social, economic, and other requirements of the Nation; (3) the adequacy of available natural resources for fulfilling human and economic requirements of the Nation in the light of expected population pressures; (4) a review of the programs and activities (including regulatory activities) of the Federal Government, the State and local governments, and nongovernmental entities or individuals with particular reference to their effect on the environment and on the conservation, development and utilization of natural resources; and (5) a program for remedying the deficiencies of existing programs and activities, together with recommendations for legislation.

Sec. 202. There is created in the Executive Office of the President a Council on Environmental Quality (hereinafter referred to as the "Council"). The Council shall be composed of three members who shall be appointed by the President to serve at his pleasure, by and with the advice and consent of the Senate. The President shall designate one of the members of the Council to serve as Chairman. Each member shall be a person who, as a result of his training, experience, and attainments, is exceptionally well qualified to analyze and interpret environmental trends and information of all kinds; to appraise programs and activities of the Federal Government in the light of the policy set forth in title I of this Act; to be conscious of and responsive to the scientific, economic, social, esthetic, and cultural needs and interests of the Nation; and to formulate and recommend national policies to promote the improvement of the quality of the environment.

Sec. 203. (a) The Council may employ such officers and employees as may be necessary to carry out its functions under this Act. In addition, the Council may employ and fix the compensation of such experts and consultants as may be necessary for the carrying out of its functions under this Act, in accordance with section 3109 of title 5, United States Code (but without regard to the last sentence thereof).

(b) Notwithstanding section 1342 of Title 31, the Council may accept and employ voluntary and uncompensated services in furtherance of the purposes of the Council.

Sec. 204. It shall be the duty and function of the Council —

(1) to assist and advise the President in the preparation of the Environmental Quality Report required by section 201 of this title;

(2) to gather timely and authoritative information concerning the conditions and trends in the quality of the environment both current and prospective, to analyze and interpret such information for the purpose of determining whether such conditions and trends are interfering, or are likely to interfere, with the achievement of the policy set forth in title I of this Act, and to compile and submit to the President studies relating to such conditions and trends;

(3) to review and appraise the various programs and activities of the Federal Government in the light of the policy set forth in title I of this Act for the purpose of determining the extent to which such programs and activities are contributing to the achievement of such policy, and to make recommendations to the President with respect thereto;

(4) to develop and recommend to the President national policies to foster and promote the improvement of environmental quality to meet the conservation, social, economic, health, and other requirements and goals of the Nation;

(5) to conduct investigations, studies, surveys, research, and analyses relating to ecological systems and environmental quality;

(6) to document and define changes in the natural environment, including the plant and animal systems, and to accumulate necessary data and other information for a continuing analysis of these changes or trends and an interpretation of their underlying causes;

(7) to report at least once each year to the President on the state and condition of the environment; and

(8) to make and furnish such studies, reports thereon, and recommendations with respect to matters of policy and legislation as the President may request.

Sec. 205. In exercising its powers, functions, and duties under this Act, the Council shall —

(1) Consult with the Citizens' Advisory Committee on Environmental Quality established by Executive Order No. 11472, dated May 29, 1969, and with such representatives of science, industry, agriculture, labor, conservation organizations, State and local governments and other groups, as it deems advisable; and

(2) Utilize, to the fullest extent possible, the services, facilities and information (including statistical information) of public and private agencies and organizations, and individuals, in order that duplication of effort and expense may be avoided, thus assuring that the Council's activities will not unnecessarily overlap or conflict with similar activities authorized by law and performed by established agencies.

Sec. 206. Members of the Council shall serve full time and the Chairman of the Council shall be compensated at the rate provided for Level II of the Executive Schedule Pay Rates (5 U.S.C. 5313). The other members of the Council shall be compensated at the rate provided for Level IV of the Executive Schedule Pay Rates (5 U.S.C. 5315).

Sec. 207. The Council may accept reimbursements from any private nonprofit organization or from any department, agency, or instrumentality of the Federal Government, any State, or local government, for the reasonable travel expenses incurred by an officer or employee of the Council in connection with his attendance at any conference, seminar, or similar meeting conducted for the benefit of the Council.

Sec. 208. The Council may make expenditures in support of its international activities, including expenditures for: (1) international travel; (2) activities in implementation of international agreements; and (3) the support of international exchange programs in the United States and in foreign countries.

Sec. 209. There are authorized to be appropriated to carry out the provisions of this chapter not to exceed $300,000 for fiscal year 1970, $700,000 for fiscal year 1971, and $1,000,000 for each fiscal year thereafter.

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